INTEGRATED WATER RESOURCE DEVELOPMENT
A PLAN FOR ACTION

REPORT

OF

THE NATIONAL COMMISSION FOR INTEGRATED WATER RESOURCES DEVELOPMENT

VOLUME - I

सत्यमेव जयते

GOVERNMENT OF INDIA

Ministry of Water Resources

New Delhi

SEPTEMBER, 1999

I.P.(N) Dte.

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R.K.Parashar	Director General,National Water Development Agency	Member-Secretary

FOREWORD

Enormous quantities of water in addition to existing uses are required for meeting the basic human needs of water for life and health and for producing food, shelter and clothing for a large and growing population in our country. More water is needed for energy generation, for crucial industrial activities and, even more essentially, for maintaining an environment and eco-system conducive to sustaining all forms of life. We have yet not been able to meet fully and satisfactorily even the needs of drinking water in all parts of the country.

If meeting the water requirements for sustenance of life and development over time is a challenge, it is not because nature has been too niggardly in bestowing this valuable resource on us, but more because we have been wanting in using this resource with care and vision. We have not adequately attempted an integrated approach to water use with a perspective of overall development. We have not paid serious attention to developing legal and institutional framework for rational use of water, and above all, we have been slow and wasteful in our programmes and projects for the development of this precious resource.

The setting up of the National Commission for Integrated Water Resources Development Plan, the first national Commission on water, has not come too soon. The key words in the name of the Commission as well as in the terms of reference are "integrated water resources development", "national perspective" and "uneven temporal and spatial distribution of water". The preamble of the office memorandum of the Government of India, Ministry of Water Resources, setting up the Commission, states, inter alia, "Integrated Water Resources Development of both, surface and ground water, can optimize benefits resulting in economic use of available water". Accordingly, the Commission set itself the task of evolving a framework of development with the objectives of maximizing the availability of utilizable water with due regard to harmony with nature and environmental sustainability, taking an integrated view of water from all sources. The task required balancing the water demands for different purposes, keeping national perspectives in view and meeting the needs of water-short areas in the country, optimising benefits and ensuring economical use and conservation of this increasingly scarce resource.

We have presented in our Report a framework of action plan for policy formulation, legal and institutional set up, financial planning and prioritization of projects for integrated development and augmentation of utilizable water resources, taking care of the human, social, regional and environmental concerns. We believe strongly that we would be able to move in the direction of our objectives to the extent that the suggested action plan is implemented during the next three to five years.

After the first few months of its inception, when the Commission was still groping with the ways of proceeding with the task, the mantle of chairing the Commission fell on my shoulders. It was an honour and a privilege, but acutely aware of my limitations in relation to the enormity of the task, I was rather overwhelmed. However, as the work of the Commission proceeded and discussions in the Commission started, the mist on the road ahead started clearing. The Commission was fortunate in getting members, each one of whom is an eminent and well-known expert in his own area of work and interest. Members represented disciplines such as engineering, water resource planning and policy, finance, law & water institutions, water related international issues, environment & forests and economics. It was a great learning experience for me to sit through the deliberations of the Commission.

After a few preliminary meetings to decide on the method of work and the organizational arrangements and to further detail out the terms of reference, the Commission divided the work into a number of Working Groups. Each Working Group was chaired by a Member and had a full time Resource Person drawn from very competent body of experts from all over the country. The Working Group Reports were discussed in meetings of the Commission extended over 2 to 5 days at a time. The Working Group Reports dealt with the assigned subjects comprehensively and competently, and together, all these Reports provided the material for further detailed deliberations in the Commission and for drafting of Chapters of the final Report. The Commission took a collective view on each and every issue. Each chapter was read from first to last page in meetings of the Commission, each session of which extended over days. I have great pleasure in reporting that almost on every issue we were able to reach a point of convergence. There was a lot of give and take in our views and the process greatly enriched our knowledge and understanding of matters.

The Commission benefited from the vast amount of literature available on the subject. The Commission also fully utilized all the large amount of work done by National Water Development Agency. The Commission was greatly helped by experts available in the Ministry of Water Resources, Central Water Commission, Central Ground Water Board, and other water related institutions and organisations. In order to further enlarge the reach of our knowledge, we co-opted more experts either as permanent invitees or as members of the Working Groups. The Commission also organized four regional Seminars to get a feel of the thinking and perceptions of the people from all walks of life in different parts of the country.

The Commission has, in the very first Chapter of this Report, listed and acknowledged all the help received from individuals and organizations. Here, I would like to personally thank the members of the Commission for their excellent cooperation and undiminished enthusiasm till the end.

Members were very busy people, each with many other important preoccupations, and yet they found time to attend most of the meetings and to contribute substantially to the writing of the final Report.

I would particularly like to thank Shri V. Ramachandran, member of the Commission. Shri Ramachandran agreed, on my request, to read through the entire volume of the Report thoroughly with a view to ensuring consistency and flow of thoughts, and finally to edit it from the language point of view. His photographic memory was particularly useful in this task. It was a painstaking work he put in.

The Member Secretary of the Commission Shri R.K. Parashar had the responsibility of organizing the work of the Commission, which included supervising the office of the Commission, procuring statistical material and information, getting the papers and maps prepared, organizing the four Regional Seminars and liaising with the Ministry of Water Resources and other Government offices. I would like to record my appreciation for the most efficient and excellent way Mr. Parashar performed his tasks.

I would finally like to thank the Ministry of Water Resources and its Secretaries, Shri Mata Prasad, earlier, and Shri Zafrul Hasan, later, for the wholehearted support they always extended to the Commission. Both of them attended the meetings of the Commission as permanent invitees. Shri Zafrul Hasan, being an engineer, also contributed substantially to the deliberations on technical issues.

I record my personal appreciation of all the help and cooperation that we in the Commission received from many individuals, organizations and institutions. But for such help and support, the task could not have been performed.

S. R. Hashim

(S.R. Hashim)

September 24, 1999

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Executive Summary

While there have been Commissions on agriculture, irrigation and floods earlier, this is the first National Commission on Water Resources. The task was to look at water in its diverse sources and uses and suggest measures for its integrated development and management. The Report gives the framework of an action plan for policy formation, legal and institutional set up, financial planning and prioritisation of projects for integrated development and augmentation of utilisable water resources, taking into account human, social, regional and environmental considerations.

At the end of the twentieth century, the world faces a number of challenges affecting the availability, accessibility, use and sustainability of its fresh water resources. These could have serious implications for the present and future generations of humanity as also for natural ecosystems. India, which has 16 percent of the world's population, has roughly four percent of the world's water resources and 2.45 percent of the world's land area. The distribution of water resources in the country is highly uneven over space and time. Over 80 to 90 percent of the runoff in Indian rivers occurs in four months of the year and there are regions of harmful abundance and acute scarcity. Vast populations live in latter areas. The country has to grope with several critical issues in dealing with water resource development and management. While they are discussed in detail in the report and certain approaches, solutions and actions are also suggested, it is clear that the issues would be confronted more satisfactorily to the extent that we are able to develop a national consensus. Major attitudinal and organisational changes would be necessary to deal adequately with all the issues and concerns. In this context, the controversy over and polarisation of views on large projects and local watershed and water resource conservation and development is unfortunate. The two are complementary to each other and there is need for the whole range of structures- large to small- in trying to meet people's requirements.

The National Water Policy (1987) was a good first step in the direction of evolving a national consensus. But it has largely remained unimplemented. Meanwhile, several new issues and concerns like those relating to displacement and rehabilitation, not earlier addressed in the policy, have emerged. It is urgently necessary to revise the National Water Policy and attempt a new document, instead of going in for additions and amendments. The Policy should be accompanied by a blue print for action.

Water Availability and Requirement

Since river basins are the natural hydrologic units, estimate of water resources has to be made basinwise. The entire country was divided earlier by CWC into 20 river basins. This was revised and in consultation with the CWC, 24 basins are now recognised.

Annual mean flow in a river basin is reckoned as water resource of the basin. After reviewing the estimates of average flows made by several agencies, the CWC's estimates are adopted with some modification. The total water resource of the country is estimated now at 1952.87 Km^3 or 1953 Km^3. The water resource of Ganga-Brahmaputra-Meghna basin is estimated as 1200 Km^3 which is 60 percent of the total water resource flows while the basin occupies 33 percent of the geographical area. Water resource of west flowing rivers south of Tapi is estimated as 200 Km^3, which is 11 percent of the total water resource, whereas the basin occupies only three percent of the geographical area of the country. The remaining 64 percent of the area has a water resource of only 553 Km^3.

The utilisable flow from a basin can be taken as the quantum of water that can be withdrawn from its place of natural occurrence. After considering the storages, barrages and diversions that have been constructed, those that are under construction and the identified future projects, the estimate of 690.31 Km^3 made by the CWC as utilisation from conventional schemes of water resources development is accepted.

Ground water is an important source of water in many places. For use and development, only annual replenishable component of ground water is considered. The total replenishable ground water is estimated as 432 Km^3. Out of this, 396 Km^3 is estimated as utilisable – 71 Km^3 (15 percent) for domestic, industrial and other uses and 325 Km^3 (90 percent of the balance) for irrigation. Nearly 50 percent of irrigation in the country is by ground water. Ground water also occurs in the aquifer zones below the zone of water level fluctuation, called static ground water. CGWB has recently made preliminary estimates of static ground water available in the country. The studies have to be completed at the earliest, especially in arid and drought prone areas.

Requirement is closely related to population, demand for food, production of non-food agricultural and industrial items, production of energy and improvement in the quality of life and preservation of ecology and environment.

Estimates of water requirements have been made for the years 2010, 2025 and 2050 at the national level. Several assumptions have had to be made to arrive at the figure of total water requirement for the country as a whole. While estimating demand by different sectors, aspects of management and technology are given due consideration. Also, international and Indian norms and standards have been taken into account. Requirement of food production would mainly depend upon country's population, per capita income and changes in dietary habits. After examining latest trends and the views expressed by different demographers, the higher and lower limits of India's population in the year 2050 corresponding to those estimated by Visaria and Visaria (standard) and United Nations (low variant) that is, 1581 million and 1346 million respectively are followed. Long term estimates for food demand extending upto year 2050 were made through a special study based on three scenarios of economic growth rate.

With the goal of food self-sufficiency at macro level, the demand estimates were converted into the domestic supplies, the latter being a factor of arable area and yield per hectare. Keeping in view the past trend and incremental changes in land use, cropping pattern, irrigation conditions, suitable assumptions were made for estimation of water requirement for irrigation. Water requirement for irrigation has been estimated between 628 Km^3 (Low Demand Scenario) and 807 Km^3 (High Demand Scenario) for the year 2050.

Keeping in view the existing national average of water supply and various suggested norms, we have suggested the final goal of providing 220 lpcd for the urban areas and 150 lpcd for the rural areas in a phased manner. The total water requirement for domestic use for rural and urban areas is estimated at 111 Km^3 and 90 Km^3 in two population scenarios for the year 2050.

On account of serious dearth of information on the present use of water by industries and uncertainity about the future growth and composition of manufacturing activities, it is extremely difficult to estimate future water requirement of industries. The water requirement for industrial development estimated is 81 Km^3 for the year 2050. Water requirement for energy/power sector has been estimated for high and low demand scenarios as 70 Km^3 and 63 Km^3 respectively for the year 2050.

The requirement of flow in navigation water channel needs are mostly expected to be met by seasonal flows in various river systems or canals. However, taking into account the actual releases downstream of Farakka Barrage, as an example, the requirement of water for the year 2050 has been projected as 15 Km^3.

Requirement of water for abatement of pollution and managing quality of waters in rivers and other water bodies has been assumed as 20 Km^3 for the year 2050 in the absence of reliable and adequate data. The evaporation losses from reservoirs have been estimated as 76 Km^3.

The total water requirement of the country, thus, would be 694 to 710, 784 to 850 and 973 to 1180 Km^3 by the years 2010, 2025 and 2050 respectively depending on the low demand and high demand scenarios. Irrigation would continue to have highest water requirement, between 628-807 Km^3 (or about 68 percent of total water requirement) followed by domestic water use, including drinking and bovine needs, at about 90-111 Km^3 (or about ten percent of total water requirement) in the year 2050. The projected water use per capita per year in the year 2050 would be about 725-750 m^3 as compared to about 650 m^3 at present.

The water requirements assessed at three levels, namely, national, basin and state give approximately the same results.

The water balance basinwise and water requirements statewise have been estimated keeping in view the overarching objective of achievement of food self-sufficiency at the national level. The basins' and states' projections are based on major assumptions and should be treated as first approximations. They do not and cannot take into account impact of unforeseen technologies. It would be desirable to review these estimates regularly, say, at the interval of 5-10 years.

The country's total water requirement in the year 2050 barely matches the estimated utilisable water resources. It is of paramount importance that we should aim at reducing water requirement to the low demand scenario. While there appears to be no need to take an alarmist view, three major considerations have to be kept in the forefront while formulating an integrated water policy. First, that the balance between the requirement and availability can be struck only if utmost efficiency is introduced in water use. Second, average availability at the national level does not imply that all basins are capable of meeting their full requirement from internal resources. Third, the issue of equity in the access to water, between regions and between sections of population assumes greater importance in what is foreseen as a fragile balance between the aggregate availability and aggregate requirement of water.

Irrigation, Flood Management, Hydropower and Navigation

India has long history of irrigation development. Grand Anicut across Cauvery river delta built in 2nd century was amongst the earliest irrigation systems. Development of irrigation continued at a slow pace until partition. Since Independence, the government gave highest priority to irrigation to tide over heavy food deficits and consequent imports of food grains. Countrywide programmes were taken up which included large river valley projects and medium and minor schemes including ground water structures. In the States ground water schemes received priority during the sixties when green revolution occurred and it gathered momentum with increased availability of cheaper power with the spread of rural electrification. Since partition, irrigated area in India rose from 22.60 Mha to 80.76 Mha upto June 1997, against the ultimate target of 140 Mha, of which ground water development has been nearly 50 percent. Such a large programme has been implemented almost entirely with indigenous technology and equipment.

During the course of implementation of projects, many lessons were learnt and measures for improvement and modernisation were taken. Comprehensive data and information were collected for this Report and analysed. Several recommendations on development and management are made. On the development side, a large number of irrigation multipurpose projects were taken up by the States which were beyond their capacity of funding. As a result, there are inordinate delays in completion resulting in time and cost overruns. A few projects which were receiving external assistance were provided with relatively larger outlays. The establishment costs also mounted up. The available resources were applied on new projects and as a result, management issues were relegated to the background. There was disproportionately larger lag in irrigation utilisation compared to potential created. Irrigation statistics also showed differences amongst figures collected by the Irrigation Departments and those by the Land Use Statistics. Measures have been recommended in the Report for reducing the lag and suggestions are given for reconciliation of differences in statistics, reported by different agencies. The performance evaluation of minor irrigation is overdue and a modernisation programme requires to be formulated. Tanks have to be renovated and have to be handed over to beneficiaries, who can carry forward these programmes largely from funds released by the GOI under various schemes of rural development and maintain them through their own efforts.

Various remedial measures for prevention as well as reclamation of water logged areas have been recommended. Here also there is lack of appropriate data. The measures to prevent water logging and drainage system are best taken during the construction phase. Suggestions have been made to prevent and reclaim land affected by intrusion of salinity in the coastal areas and also the problems arising out of pollution of water from industrial and municipal effluents. Much greater effort and attention needs to be given to management aspects of irrigated agriculture both from the technical point of view and the involvement of the users.

The command area development programme introduced in the seventies for stepping up pace of utilisation of potential created and for improvement in various on- farm activities as well as for providing various agricultural inputs including water to the farmers has been reviewed. An important finding is that there is great scope for upgrading management practices and improving water use efficiency. A reform agenda is suggested which includes technological improvements, institutional reforms and financing of irrigation schemes including private sector participation. The technological improvements include rehabilitation and modernisation of existing irrigation systems including old tanks, upgrading of maintenance programme, cautious adoption of telemetry, remote control and canal automation for making efficient water use, and ensuring equitable distribution. It also includes improvements in planning, designing and construction technologies. The institutional improvements lay stress on switch-over to participatory irrigation management as early as possible and the reforming and restructuring of the state irrigation departments. Important recommendations are made on the composition, legal support and autonomy of Water Users' Associations (WUAs). While dealing with irrigation- related issues, it is recognised that water supply and drinking water has highest priority of use and that use of water should be optimized taking into consideration the possibilities of use of water for different purposes such as, industrial use, hydro-power, flood control, navigation etc., besides irrigated agriculture. The environmental issues have also been kept in mind with a view to preserving and enhancing the environment to the extent possible while going ahead with development.

Of the flood prone area of 34 Mha in the country, reasonable protection has been provided to about 1/3rd of the area by now. Although large outlays have been spent on flood control, flood protection and catchment protection works, it has been found that there is no complete solution to provide total protection from floods. The strategy should aim at efficient management of floods, flood-proofing including disaster preparedness and response planning, flood forecasting and warning and other nonstructural measures such as disaster relief, flood fighting including protection of public health and introduction of flood insurance. The efficacy of providing flood cushion in the reservoir and of flood embankments are dealt with in the Report. It is noted that flood forecasting system administered by the CWC has been very beneficial. The modernisation of flood-forecasting system based on telemetry and satellite communication is recommended. Efficient flood routing through the large reservoirs is also stressed. There is considerable scope for improvement in the collection and reporting of flood damages, which are often exaggerated. Emphasis should shift to peoples' participation in flood management. It is noted that little progress has been made on flood zoning for rational management of floods including control of man made activities within different zones.

Hydro-power is one of the important uses of water and its advantages are well known. A certain proportion of hydro-power is essential in the regional power generation grid because of its inherent advantage in providing peak energy during peak hours. However, in spite of large hydro-power potential of nearly 84,000 MW at 60 percent load factor, the present development has been to the tune of only 13,000 MW. There is also considerable scope for providing pumped storage schemes with a total installed capacity of 94,000 MW. This can meet peak requirements to a very large extent resulting in saving in new installation of fossil fuels and other modes of power generation. The need to step up the pace of development of hydro-power projects is stressed in the Report.

Navigation is instream use of water providing navigable inland water way. Inland navigation is the cheapest mode of transport and should receive due priority in the regions where such movement is possible. Inherent advantages of inland navigation are lower operational costs, fuel conservation and better safety. Inland navigation should be encouraged by treating it as a nascent industry for some years, until its use becomes larger and viability improves so that private investment could also be attracted.

Domestic Requirements

Safe water is essential for sustenance of life and is needed in the households for drinking, cooking, washing and cleaning besides bovine and horticultural needs. The requirement is not very large overall compared to the requirements for all uses. The question is one of water availability, cost of development and efficiency of management.

Almost hundred percent coverage in both water supply and sanitation, though recommended by the Environment Hygiene Committee as early as in 1949, is yet to be achieved. Progress to the extent of 90 percent for urban water supply and 50 percent for urban sanitation is reported to have been achieved. The coverage, however, varies widely both in class–I and class-II cities. The variation in the per capita water supply ranges from 9 – 584 lpcd in urban areas and from 5 - 70 lpcd in rural areas. The Ninth Plan strategy is to have 100 percent coverage in sustainable water supply, ensuring adequacy in terms of minimum per capita consumption norms. The Ninth Plan provision of Rs.39,155 crores is inadequate and the requirement will have to be met by involvement of the beneficiaries and fiscal interventions, as private sector investment is shy to enter the field even in big cities, because of very low water rates and ingrained resistance to increase in rates.

The management issues are more critical. Wide spread dissatisfaction among consumers is the result of improperly managed water supply systems, where people are forced to resort to alternate means or supplementary sources for collection of water in sumps and overhead tanks at considerable costs. It is so because 17-44 percent of total flow in distribution system is lost due to leakages in the mains, communication and service pipes and leaking valves as brought out by NEERI while conducting pilot studies on leaks in the distribution systems of 13 cities in India. The need for according high priority to maintenance and leak detection and preventive measures is obvious. The utilities have to adopt a number of conservation measures. Demand management through pricing is an aspect which needs particular attention. Public awareness and participation especially of women has to be ensured through a massive campaign of communication through all available media. To arrest the fall in ground water table, measures like artificial recharge and rainwater harvesting have to be encouraged.

Potable water and adequate sanitation facilities undoubtedly reduce spread of diseases such as cholera, typhoid, infectious hepatitis, and dysentery. Chances of contamination in urban water supply system have to be reduced by adopting a variety of measures as indicated. Institutionalising the system of water quality monitoring and surveillance will prove a strong deterrent to over exploitation of ground water, which is the principal source of supply in rural areas and gets contaminated from point and non-point sources. Cheaper alternatives for human waste disposal, namely, oxidation ponds or waste stabilisation ponds and UASB technology need to be examined and experimented upon with a view to evolving affordable systems that can provide universal sanitation coverage in the near future. New technologies like Duckweed-Pond Technology, utilising raw sewage for forestry and Artificial Wet Lands/ Root Zone Technology should be tried wherever possible.

Water for Industrial Uses

Water requirement for industries in India although insignificant when compared to the demand for other uses like agriculture creates problems by creation of point loads on available resources. Water use in industries is mostly of non-consumptive nature and with suitable treatment can be recycled and re-used by process industries for their requirements of processing, cooling, boiler feed and other miscellaneous uses. Cost effective strategies have been demonstrated and should be adopted by industry. Tariffs have to be prescribed such that industry is compelled to look into technological interventions leading to reduced use per unit production of waste water, which will further reduce generation of pollution load and consequent cost of treatment. National bench marks for water consumption and water re-use in each of the 17 identified categories of industries are required to be fixed and efforts made to achieve them within a specified time frame.

Hazardous waste management is another important aspect of industrial waste management. Preliminary data gathered by MOEF, CPCB and institutions like NEERI and NPC suggest that the disposal methods currently practised are not environmentally compatible. Sites for disposal of hazardous wastes are not also readily available. Industrial zoning should be done in such a manner that water intensive industries are not located in arid and semi-arid areas. In the latter areas, Green category of industries have to be promoted.

India too has entered the era of desalination in the last three decades. A large number of the installed plants are not working to expectations and could not supply potable water to village/community as per the contracts. The reasons have been gone into by evaluation studies and are remediable. Improvement of technologies has also made it possible not to abandon desalination as a possible option and costs are also going down.

Local Water Resources Development and Management

The need for and benefits from conjunctive use of canal water and local water resources, like those from tanks and ponds and ground water, are generally recognised. With the emphasis on large dams and canal systems, the importance of tanks and other local resources waned. The revival of local systems through integrated watershed development is vital for a number of reasons. The renovation and modernisation of tanks and other local water resources should be taken up as a priority task.

After the projects under the Damodar Valley Corporation, a series of integrated development projects for local areas were started in 1970s and early eighties, first by the Ministry of Agriculture and ICAR and later by some other Ministries. There have also been several externally aided projects funded by the World Bank, EEC, KFW, DANIDA, SDC and ODA. A number of social activists and voluntary organisations have shown growing interest in integrated watershed development either in itself or as part of integrated development of a village or area. Sukhomajri, Tejpura, Nalgaon, Daltonganj, Ralegon Siddhi, Jawaja, Adgaon, Alwar etc. are well known examples and have been widely discussed and written about.

The story of watershed development undertaken thus far, is a mixed one of success and failure, also of initial success and later decline and initial failures and later revival. Compared to government programmes, the projects undertaken by local communities, voluntary organisations and activists were more relevant to each location, had much greater people's involvement and were flexible and innovative. They have also shown keenness to evolve cost-effective techniques and to use local traditional knowledge. They had also several important lessons.

A major reformulation of priorities and programmes and restructuring of institutions and operational means are vital for integrated local watershed development. While every effort should be made to complete the ongoing major projects within a reasonable time-frame, and drinking water needs have to be dealt with urgently, due importance should be given to local water planning, with the ultimate aim of making each rural area manage its own water needs as far as possible, through water-harvesting and conservation measures. The thrust should be towards bringing about a vast number of local initiatives.

The integration of rural area programmes into a single umbrella programme, the inclusion of integrated watershed development as an integral component of it and the details thereof are presented in the Report. The entire treatable area in the country could be brought under integrated watershed development in about 15 years.

Future direction of efforts will involve radical changes in approaches and attitudes and in methods of funding and implementation. It would not, therefore, be easy to get it accepted. However, such changes are vital both for the success of democratic decentralisation under implementation since the constitutional amendments of 1992 and for all rural area development programmes including integrated watershed development.

Interbasin Transfers

In view of large disparities in the availability of water in different river basins, inter basin transfer of water has been receiving attention. However, it will not be possible to persuade States to spare water till their own demands are met to the maximum possible extent. In basins with possible surpluses, optimal utilisation of land and water has first to be aimed at, subject to the condition that proposals for utilisation are not based on impractical engineering, for example, storage requirements for which reservoir sites are not available or involve very high lifts.

After meeting all the essential requirements, if there is surplus water available in the basin, its transfer to other basins may be considered. For deficit basins, the aim would be to meet domestic and industrial demand in full, but to achieve a lower cropping and irrigation intensity than in case of well endowed or surplus basins. The overall approach is that economic development of no part of the country should be constrained by shortage of water, at the same time the pattern of development could be different in States having adequate water and those to which water may have to be transferred at high cost.

The National Perspective brought out by the Ministry of Water Resources has two main components, (a) Himalayan Rivers Development and (b) Peninsular Rivers Development. The Himalayan Rivers Development envisages construction of storage reservoirs on the main Ganga and the Brahmaputra and their principal tributaries in India and Nepal along with interlinking canals to transfer surplus flows of the eastern tributaries of the Ganga to the west. Peninsular component envisages interlinking of Mahanadi-Godavari–Krishna-Cauvery rivers, interlinking of west flowing rivers north of Bombay and south of Tapi, interlinking of Ken-Chambal and diversion of other west flowing rivers.

The Himalayan component data are not freely available but on basis of published information it appears that this component may not be feasible for the period of review up to year 2050. The Peninsular component of the proposals for Interbasin Transfer is reviewed in detail. Nine links are proposed for interlinking east flowing Peninsular rivers. These linkages involve construction of five dams and nine link canals. The head works will submerge 2.5 lakh ha and require rehabilitation of more than 4.5 lakh persons. The links will also require agreements amongst all the concerned States and such concurrence would be facilitated by some form of quid pro quo.

Water balances have been prepared for six east flowing peninsular rivers which are involved in the nine links to determine the extent of deficit or surplus. For each of these river basins, mean annual flow, 75 percent dependable flow, utilisable surface water and replenishable ground water are given by CWC, NWDA and CGWB. Water balance has been worked on the basis of certain parameters, that are explained in the report, regarding irrigation intensity, increase in irrigated area, likely cropping patterns, irrigation efficiencies and return flows.

As regards east-flowing peninsular rivers, the studies indicate that based on mean annual flows except for Krishna (if irrigation intensity is adopted at a rather high 45 percent), Cauvery and Vaigai, the balances are positive in other cases. The shortage in Cauvery is 12 percent of gross demand and that in Vaigai 16 percent. These shortages result after increasing the present irrigated area to 1.4 times in case of Cauvery and 1.6 times in case of Vaigai and assuming the return flow at 60 percent of the imbalance. In case the return flow is taken as 80 percent of the imbalance, there is no shortage in Krishna and those in Cauvery and Vaigai are reduced to five and eight percent respectively. Thus, there seems to be no imperative necessity for massive water transfer. The assessed needs of the basins could be met from full development and efficient utilisation of intra-basin resources except in the case of Cauvery and Vaigai basins. Some water transfer from Godavari towards the south should take care of the deficit in Cauvery and Vaigai basins. This could be accomplished by constructing a low dam at Inchampalli involving minimal submergence.

The proposed interbasin transfers from west flowing rivers south of Tapi, west flowing rivers of Kerala/Karnataka and those in the southern tributaries of Yamuna are also reviewed and commented upon.

Financial Aspects

The financial aspects of the water resources sector are a matter of very grave and urgent concern. Public investment, as a percentage of overall plan outlays, has gone down from 22.5 percent in the initial plans to 6.5 percent. Some projects started in the 1950s are still not completed. Cost and time overruns have become endemic and chronic and spill-over costs are increasing with every plan. Financial returns are negligible as a result of highly subsidised pricing of water and substandard modernisation. The returns are not even adequate to cover costs of operation and maintenance.

Maintenance has been sadly neglectged and systems are deteriorating. The application of financial resources has not been optimal, with a view to getting early benefits and there is little regard in the entire system for prudential norms and accountability. Despite repeated statements in the plan documents and in other writings and reports, the situation has deteriorated over the years. Unless urgent remedial action is taken to reverse the trend, the economy and the people will have to pay a dear price. The whole question is examined in the report on the basis of this assessment.

While public outlays have to be enhanced and better applied on the basis of prioritisation, it is necessary to augment the available resources through institutional finance, water equity or bonds, private sector participation, commercial exploitation of land and peoples' contribution and participation. At present, private sector participation will be practicable mainly in projects for industrial use and urban water supply. For field level works in major projects, minor irrigation works, repairs and renovation of tanks and watershed development, in addition to integrated uses of funds available under Rural Area Programmes, community's contribution through its involvement and participation could be significant.

A number of measures are suggested for immediate adoption to instil a measure of financial discipline in the system. These include project-wise funding, proper preparation of cost estimates including possible escalation, timely revision of such estimates, clear definition of commencement and completion of projects, insistence on preparation of completion reports and limitation on the change of scope of a project and on establishment costs. It is suggested that CWC should concentrate on major projects, leaving the States to handle all medium projects, subject to certain prescribed procedures in the case of medium projects having interstate implications.

Water used for irrigation is an economic good and its logical pricing is a key to improving water allocation and encouraging conservation. The present rates need substantial revision. After consideration of all previous reports, detailed recommendations are made. The water rates should cover the entire annual O&M cost plus one percent of the gross value of the produce in respect of cereal crops and a higher percentage in respect of others. The objective should be to move towards volumetric measurement through stages. While the general principles should thus be laid down, details should be left to be worked out in each state by an independent, statutory water pricing authority.

Legal Issues

There are a number of complex legal issues when matters regarding integrated development of inter-state rivers, allocation of river waters, interbasin transfers, utilisation of ground water, water rights and people's participation are considered. There is a suggestion that since water is a national resource and asset and a national perspective is needed for equitable development, "Water", which is now a state subject, should be included in the Union or concurrent list. It is not practicable to think of this suggestion.

What is needed is that the Union should fully exploit its powers regarding interstate rivers in the Constitution and pass laws to more effectively deal with interstate rivers.

Parliament enacted the River Boards Act, 1956, under Entry 56 of List I, to promote integrated and optimum development of waters of interstate rivers and river valleys. The Act provides only for

Advisory Boards and not for River Basin Organisations vested with powers of management. In fact, no river board, even of the advisory kind has been set up under this Act. The enactment of a law on interstate rivers, in the place of River Boards Act, called the Inter-State Rivers and River Valley (Integrated and Participatory Management) Act is strongly urged. The Act would provide for the constitution of a River Basin Organisation (RBO) for each major basin.

Parliament enacted the Inter-State River Water Disputes Act in 1956. The Act provides for setting up tribunals for the adjudication of water disputes. Experience shows that a long time is taken both in constituting the Tribunals and in giving the awards and this has been the cause for some interstate tensions for years. Also, though the jurisdiction of courts is barred by the Act, matters are taken to the higher courts on issues other than water sharing, especially in the case of specific subjects. The Sarkaria Commission, which examined the issues in great depth, made five recommendations, which were considered by the Interstate Council. The Council recommended that (i) once an application is received from a State, the Union Government should constitute the Tribunal within one year (ii) the Tribunal should give the award within a period of three years, extendable by two years (iii) the award should be given effect to in two years (iv) there should be Data Bank and Information System and (v) the Award of a Tribunal should have the same force as an order or decree of the Supreme Court.

It is urged in the Report that immediate steps be taken to amend the ISWD Act on the lines suggested by the Inter-State Council with the following additions, namely, (i) provision may be made for efforts at settlement at the river basin level, as and when RBOs are formed and (ii) when any matter is referred back to the Tribunal for clarification under Section 5(3) of the ISWD Act, the Tribunal should give its final verdict within a period of six months and the Union Government shall notify and publish the award/decision of the Tribunal within three months (iii) the Tribunals should hear the views not merely of the contestant States, but all other stakeholders, who may implead themselves in response to a public notice and who, in the judgement of the Tribunal, have a stake in the dispute.

It is felt that if the ISWD Act is amended on these lines, the process of adjudication of interstate water disputes could be expedited.

The Constitutional provisions do no specifically permit or prohibit the transfer of surplus flows from one basin to a deficit basin. No state is willing to accept that it has surplus flows over and above its requirements. It is felt that through the River Basin Organisations, the States may come together for holding serious discussions on sharing of waters including diversion to non basin States, ultimately paving way for reaching an agreement on the basis of mutual needs. The proposed Inter-State River (Integrated and Participatory Management) Act, may provide necessary legal backup to the RBOs.

The property based ground water rights and the rights claimed by the State in respect of all surface water is unsuited to conditions in which water resources are scarce and fierce competition among various uses exists. So far as the major and medium rivers and streams are concerned, the State may continue to have the right of regulation, collection, retention and distribution of water; however, small rivers and minor streams could be managed by the village communities and the laws should enable this. All ground water existing and found beneath private property is fully under the control of owner of the land. Inadequate regulatory restrictions on the exercise of private property rights in ground water result in excessive withdrawals in many areas. A participatory process in the ground water management is recommended in which the role of the State could be that of a facilitator and empowerer and the prescribing regulator and the role of the community organisation as an implementing regulatory agency of the scarce resource.

There are a few acts like the Water (Prevention and Control of Pollution) Act, The Environment Protection Act 1986, and rules such as The Hazardous Wastes (Management and Handling) in force for protecting the environment and to safeguard against the disposal of toxic and hazardous wastes. Yet, there is a large scale pollution in many stretches of various rivers. Basin states should accept the specific responsibilities for protection and control of pollution of inter-state rivers. For this purpose, more specific laws, appropriate institutional mechanisms and inter-state agreements on the lines of international agreements/conventions signed by the European countries for protecting the transboundary waters are necessary.

A survey of the relevant legal provisions shows that the major irrigation acts, do not provide for farmers' participation in irrigation management. Community involvement and participatory management implies arrangement wherein farmers can function as coequals in a participatory-cum-consultative mode. For this to happen, a number of changes will have to be made in irrigation statutes and the rules framed under them and the more important changes to be made are indicated in the Report.

Many basic issues have arisen in the context of development and management of water resources. There is no legal backing for many of these vital concerns. Some new laws and changes in the existing laws have been suggested, but a comprehensive view has also to be taken and it is recommended that a National Water Code be prepared with the assistance of the Law Commission.

Institutional Aspects

Water has diverse uses and as such, cannot be dealt under the Ministry of Water Resources alone. What is essential is coordination. For this purpose, the Ministry and its attached office (CWC) should have multidisciplinary capacity and function in an interdisciplinary way. The Central Water Commission should be restructured into a high-powered statutory interdisciplinary Commission, with maximum autonomy. The Central Ground Water Board will also be an organization linked to the restructured CWC.

The suggestion for River Basin Authorities or Bodies has not been accepted by the States, mainly because they were conceived as nominated bodies. For acceptance and ultimate effectiveness, RBOs should be representative organisations in which the concerned State Governments, Local Governments and Water Users would have representation and which would provide a forum for mutual discussions and agreements. It shall be the function of RBO to collect data, disseminate them in local languages, formulate integrative plans and consider the proposals from constituent States on various issues, including project proposals in the basin and monitor implementation of large projects. An illustrative model of an RBO and its Standing Committee is suggested in the report. Other models are possible but, what is important is the representative character.

Between field level and basin level, an intermediate organisation is suggested at the level of a sub-basin/water district. The water district management could comprise of representatives of all types of water users and the local government.

The National Water Resources Council (NWRC) is a high level Centre-State political body which can play a very useful role in bringing about consensual approaches and agreements on the sensitive subject of water. But, it meets very occasionally. The Council has held three meetings only during the last 15 years. It could be more effective by functioning through committees, groups and by enlisting the services of eminent persons for fact-finding, mediation and negotiations.

The importance of participation of users in irrigation management at the field level is widely recognised. There have been some attempts in the past to organise farmers' groups. However, many of the water user associations (WUA) became defunct for want of empowerment and resources. Andhra Pradesh has taken up necessary reforms in a big way and several other States have taken some steps. On the basis of experience gained so far, reconstitution regarding the powers, functions and responsibilities are made in the Report.

There is a growing debate on the subject of water markets, some arguing in favour and others against. There are no clear policy statements or legal measures in respect of water markets in our country. There is need to evolve a legally and institutionally enforceable system which will ensure sustainability and provide the parameters within which water markets could operate.

Project Planning and Prioritisation

There is need to make changes in approaches to project planning, in regard to allocation of water among various uses, dependability and carry over related issues, conjunctive use, water lifts, project size and viability area. The present procedures of benefit – cost analysis are too simplistic and routinised. The Planning Commission has to lay down improved procedure covering all aspects such as technical, financial, social and environmental. The working of the Technical Advisory Committees has to be made more effective, so that further delays in getting mandatory clearances regarding environment, forests etc. are avoided.

Project implementation requires considerable improvement. There is no reason why the procedures for technical appraisal, regular monitoring of physical and financial progress as well as of rehabilitation and resettlement and funding in accordance with project programming schedule, which are followed in the case of externally – aided projects, cannot be followed in all these projects also. Contract and construction management techniques also need to be improved and changes that could be made in this regard are indicated in the Report.

Gradual decline in funding of irrigation sector over the Five Year Plans led to thin spreading of funds over a large number of schemes resulting in time and cost overruns. There is an urgent need for prioritisation of ongoing and new schemes. Suitable guidelines are to be evolved for project specific funding in order of priority based on marking of identified attributes for each project. The general principles for prioritisation, the various attributes and the marks to be given to each of them are explained in detail.

The system would help to determine the order of priority. The project on top of the list should receive full funding as required for its completion, constrained only by the organisation's capacity to spend the money efficiently and effectively. Only after meeting all requirements of a higher priority project, the requirement of the low priority project would be considered.

The desirable attributes of projects receiving priority will have total of 100 marks. Method of giving marks of each attribute for a project has been devised. A detailed illustrative exercise, through a computer based Excel Programme developed by the Working Group, was made for major ongoing projects in the States of Maharashtra and Madhya Pradesh. The total of 100 marks are divided amongst accepted attributes. Attributes considered are; residual benefits, residual costs, environmental and RR action plans, inter-state aspects, plan and design network, geological investigation network, infrastructure for quality control, timely submission of revised estimates, multiplicity of purpose etc., and attributes of local importance.

Priortised major and multi purpose projects should be phased further by sub-dividing into identifiable sub-systems, namely, dam and appurtenants and for distribution network the sub-system starting from head reaches to tail reaches, each covering about 10,000 Ha. Phased sub-systems should be supported correspondingly with specific outlays for better monitoring and financial discipline. It is recommended that the Planning Commission and the Ministry of Water Resources should require each State to prioritise major projects on the basis of guidelines and system of marks for desired attributes and plan funds be released to projects only on that basis.

International Dimensions

The largest part of India's water resources is contributed by transboundary rivers which rise from, or flow into or through six of its neighbours viz. Nepal, Bhutan, Tibet/China, Myanmar, Bangladesh and Pakistan. Taking cognizance of this geo-political reality, it is obvious that no meaningful or optimal national water resource planning is possible in relation to these rivers without bilateral or regional cooperation.

The problems and types of issues that usually arise in working out such cooperation as well as those that have recently emerged or are emerging as a result of global concern for environment, bio-diversity, emission, resettlement and rehabilitation of displaced persons are indicated, as also the possible effects on such cooperation of private investments, especially by multi-national corporations.

The Ganga Treaty with Bangladesh and the Mahakali Treaty with Nepal use expressions such as no harm, equal entitlement, good neighbourliness, optimum utilisation, integrated development, mutual benefit and so on, all of which have cross-border implications.

International water law is still evolving in areas other than navigational law which is relatively better established. However, non-binding rules and principles carefully evolved over the years, such as the Helsinki Rules have provided useful guidance. So also national and inter-country agreements and court and tribunal decisions. On the recommendation of the International Law Commission regarding the draft of a Convention on Non-Navigational Uses of International Water Courses, the UN General Assembly has adopted the Convention in May, 1997. India abstained from signing the Convention, due to reservations on a few clauses. Nevertheless, international conventions and legal principles are likely to assume growing importance in diplomacy and international relations in view of emerging regional water shortages and quality issues over large areas, affecting both surface and ground water systems in an increasingly globalising world. In working out the details of treaties and agreements with our neighbours, it would be useful to draw upon many of the principles in the Convention.

Technology offers new windows of opportunity even as global environmental concerns could pose certain limitations, especially if external funding is sought. Global warming concerns have, for instance, moderated Japanese opposition to China's mammoth Three Gorges Project, in the absence of which several tens of million tonnes of "dirty" coal might be fired in thermal plants of equivalent capacity.

The Himalayan component of the NWDA studies on the proposed national water grid has trans-border implications. Water transfers would be easier and cheaper were India and its neighbours, especially Bangladesh to cooperate in this regard rather than each decide to go it alone. Like India, Bangladesh is working on a perspective development plan through its Water Resources Planning Organisation (WARPO). Nepal is similarly engaged in a long term study of optimal energy development under the aegis of its Electricity Development Authority or, more broadly, under the auspices of the Standing Committee of the National Water Resources Council chaired by the Water Resources Minister. These three national efforts are in a sense complementary and there is room for mutual collaboration in given areas and for larger optimisation and trade-offs through regional cooperation.

Rainfall, discharge and silt readings, and seismic data could usefully be exchanged among the riparian countries. Flood and disaster forecasting and warning systems could also be developed and refined. It is ncessary to get over the urge for secrecy which is normally seen in such matters.

The Chhimtuipui (Kaladan) and Manipur (Imphal) River flow into Myanmar from Mizoram and Manipur respectively. The former could conceivably provide a waterway to the sea with development.

In the northwest, under the 1960 Indus Waters Treaty, that river system was divided between India and Pakistan for the complete and satisfactory utilisation of its waters. That accord is being implemented satisfactorily. The three Western Rivers which flow through Himachal Pradesh and J & K have a considerable hydro-electric and storage potential, only a part of which has been tapped by India due to restrictions imposed by the Treaty. Attempts should be made fully to utilise the available hydro-electric potential and satisfy the full water requirements of the irrigated cropped area as permissible in the Treaty.

All these possibilities and issues call for the early completion of requisite studies in order to facilitate informed consideration and decision making.

Water Quality and Environmental Aspects

The challenge in water resource development is to balance the needs of development and those of environmental health and thereby ensure the sustainability of development. Integrated management of water resources should be based on the perception of water as an integrated part of the eco-system and as a natural resource whose quantity and quality determine the nature of its utilisation.

In order to assess the likely changes in the environmental conditions due to taking up of the projects, it is now necessary to carry out environmental impact study and submission of EIA statement and EMP is mandatory without which any project cannot be cleared for investment. EIA is a formal process to predict environmental consequences of a development activity and to plan appropriate measures to eliminate or remove adverse effects and to augment positive effects. The environmental concerns have to be internalised in a project and should not be treated as an imposition from outside.

The planning of a project has to include formulation of detailed measures to mitigate or compensate for the adverse effects of the project. Catchment treatment programmes for arresting the deterioration of catchment areas and restoring ecological balance and resettlement and rehabilitation (R&R) of displaced people need to be planned exploring all alternatives. R&R is one of the most sensitive and complex issues that arise in large water projects. Several drafts of an R&R Plan have been under consideration in the Government of India. After a review of the guidelines so far issued, the core elements of an R&R Plan are suggested in the Report.

Deteriorating water quality has become a serious problem. Water quality is basically determined by the bacterial and physico-chemical parameters. Safe water supplies and environmental sanitation are vital for protecting the environment, improving health and alleviating poverty. Water Quality criteria have been developed for various categories of beneficial uses. The relevant parameters are colour, odour, floatable material, pH, phenols and hydro carbons. Based on water quality data, 13 heavily and 26 medium polluted rivers and 26 medium polluted rivers' stretches have been identified in the country. A bio-map based on bio-assessment depicts the stretches where the deterioration of water quality has occurred and for which action for improvement is required.

Monitoring the water quality of rivers and other water bodies is most essential in restoring water quality. CPCB has a nationwide responsibility of water quality monitoring and management of rivers. Ground water quality is being monitored by CGWB. CWC is also involved in water quality monitoring. There is need for a mechanism to coordinate the work of these agencies.

A number of programmes have been initiated to restore water quality and sustain rivers, lakes and wetlands. The river cleaning programme was started with the launching of the Ganga Action Plan (GAP) Phase–I in June, 1985. It was followed by GAP Phase – II and National River Conservation Plan (NRCP) covering all major rivers of the country. The measures to be taken for more effective implementation are recommended, based on the experience with GAP Phase-I.

Lakes also constitute an important component of fresh water systems. Due to pressure of human activities, a number of lakes are shrinking or are getting polluted beyond recovery. The objective of National Lake Conservation Programme is to arrest further degradation of lakes and to revive the water body to acceptable environmental standards so that water can be utilised for different purposes. Wetlands are natural filters but these are faced with the problems of weed infestation, siltation, pollution and anthropogenic activities. Wetlands have to be regenerated by the reorientation of policy of "open access" to "common property resources". Enlarged programmes of Lake and Wetland conservation with larger outlays are recommended.

Research and Development Needs

Water resource development is to be seen not merely as a single-sector-end objective, but as a prime mover in developing larger systems with multiple linkages. This calls for a well set out multi-disciplinary research agenda covering not only technological issues but also issues of social, economic, legal and environmental concerns. A trained, motivated manpower being the backbone of any developmental activity, in the water resources sector also, there is need for human resource development. The kind of approach suggested requires multi-level training of personnel involved in the sector to undertake the challenging tasks ahead. Details of the areas in which research is needed and of HRD for improved performance are considered in the Report.

The challenge in water sector is to simultaneously take care of the needs of development and environmental health and thereby ensure the sustainability of development. The problems are not beyond the present state of knowledge and technology. Given the needed political will and societal awareness, the nation shall be able to meet the challenge.

Abbreviations

A

A	-	Area
ADB	-	Asian Development Bank
AIBP	-	Accelerated Irrigation Benefit Programme
AICRP	-	All India Co-ordinated Research Project
AI/DC	-	Area Irrigated per Day Cusec
AP	-	Annual Plan
ARDC	-	Agriculture Refinance & Development Corporation
ARWSP	-	Accelerated Rural Water Supply Programme
AWR	-	Annual Water Resources

B

BBMB	-	Bhakra Beas Management Board
BCM	-	Billion Cubic Metres
B/C Ratio	-	Benefit Over Cost Ratio
BFA	-	Beneficiary Farmers' Association
BGL	-	Below Ground Level
BHEL	-	Bharat Heavy Electricals Ltd.
BIS	-	Bureau of Indian Standards
BLD	-	Billion Litre per Day
BMWP	-	British Biological Monitoring Working Party
BOD	-	Biochemical Oxygen Demand
BOO	-	Build, Operate and Own
BOOT	-	Build, Operate, Own and Transfer
BOT	-	Build, Operate and Transfer
BWS	-	Bulk Water Supply

C

CAD	-	Command Area Development
CADA	-	Command Area Development Authority
CAG	-	Comptroller & Auditor General
CBIP	-	Central Board of Irrigation and Power
CBL	-	Canal Bed Level
CCA	-	Culturable Command Area
CCEA	-	Cabinet Committee for Economic Affairs
CEA	-	Central Electricity Authority
CETP	-	Common Effluent Treatment Plant
CGWA	-	Central Ground Water Authority

CGWB	-	Central Ground Water Board
CIDA	-	Canadian International Development Agency
CII	-	Confederation of Indian Industries
CIWTC	-	Central Inland Water Transport Corporation
CMC	-	Citizen Monitoring Committee
CMERI	-	Central Mechanical Engineering Research Institute
COD	-	Chemical Oxygen Demand
CPCB	-	Central Pollution Control Board
CPHEEO	-	Central Public Health and Environmental Engineering Organisation
CPM	-	Critical Path Method
CRSP	-	Central Rural Sanitation Programme
CSD	-	Commission on Sustainable Development
CSMCRI	-	Central Salt and Marine Chemical Research Institute
CSSRI	-	Central Soil Salinity Research Institute
CSSRVP	-	Centrally Sponsored Schemes of Soil Conservation in the Catchments of River Valley Projects
Cumec	-	Cubic metre per second
Cusec	-	Cubic feet per second
CWC	-	Central Water Commission
CWDP	-	Comprehensive Watershed Development Project
CW&PC	-	Central Water & Power Commission
CWPRS	-	Central Water and Power Research Station

D

DANIDA	-	Danish Development Assistance
DDP	-	Desert Development Programme
Delta	-	Depth of Irrigation Measured at Canal Head
DISNET	-	Distribution Network
DO	-	Dissolved Oxygen
DPA	-	Drought Prone Area
DPAP	-	Drought Prone Area Programme
DPC	-	District Planning Committee
DPR	-	Detailed Project Report
DRDA	-	District Rural Development Agency
DRPC	-	Cooperation for the Protection and Sustainable Use of the River Danube
ds/m	-	Decisiemen per metre
D/S	-	Downstream
DVC	-	Damodar Valley Corporation
DW	-	Dug Well

E

EA	-	Externally Aided
EAS	-	Employment Assurance Scheme
ECE	-	Economic Commission of Europe
ED	-	Electro Dialysis
EEC	-	European Economic Community
EGS	-	Employment Guarantee Scheme
EIA	-	Environmental Impact Assessment
EMP	-	Environment Management Plan
ERM	-	Extension, Renovation and Modernisation
ET	-	Evapotranspiration
ETc	-	Evapotranspiration of Particular Crop
ETo	-	Potential Evapotranspiration / Evapotranspiration of Reference Crop

F

FAO	-	Food and Agriculture Organisation
FICCI	-	Federation of Industry and Chamber of Commerce of India
FO	-	Farmers' Organisation
FSL	-	Full Supply Level

G

GAP	-	Ganga Action Plan
GBM	-	Ganga – Brahmaputra – Meghna
GBWS	-	Ganga – Brahmaputra Water Studies
GCA	-	Gross Command Area / Gross Cropped Area
GDP	-	Gross Domestic Product
GEMS	-	Global Environmental Monitoring System
GFCC	-	Ganga Flood Control Commission
GI	-	Galvanised Iron
GIA	-	Gross Irrigated Area
GIR	-	Gross Irrigation Requirement
GO	-	Government Order
GOG	-	Government of Gujarat
GOI	-	Government of India
GSA	-	Gross Sown Area
GSFC	-	Gujarat State Fertilizers and Chemcials Ltd.
GW	-	Ground Water
GWDT	-	Godavari Water Disputes Tribunal

H

ha	-	Hectare
ha m/sq km/year	-	Hectare Metre per Square Kilometre per Year
HFL	-	High Flood Level
HOPP	-	Haryana Operational Pilot Project
hr	-	Hour
HRD	-	Human Resources Development
HUDCO	-	Housing & Urban Development Corporation

I

ICAR	-	Indian Council of Agricultural Research
ICICI	-	Industrial Credit and Investment Corporation of India
ICID	-	International Commission on Irrigation and Drainage
ICMR	-	Indian Council of Medical Research
ICPDR	-	International Commission for the Protection of the Danube River
ICPR	-	International Commission for the Protection of the Rhine
IDBI	-	Industrial Development Bank of India
IFPRI	-	International Food Policy Research Institute
IGCCC	-	Inter – Governmental Conference on Climate Change
IGNP	-	Indira Gandhi Nahar Project
ILC	-	International Law Commission
IL & FS	-	Infrastructure Leasing and Financial Services
IMT	-	Irrigation Management Transfer
INTACH	-	Indian National Trust for Art and Cultural Heritage
IPPs	-	Independent Power Producers
IRAP	-	Integrated Rural Area Programme
IRDP	-	Integrated Rural Development Programme
IRR	-	Internal Rate of Return
IS	-	Inter-State / Indian Standard
ISI	-	Indian Standards Institution
ISPWD	-	Indo – Swiss Participative Watershed Development Project
ISWD	-	Inter-State Water Disputes
IWAI	-	Inland Waterways Authority of India

IWDMP	-	Integrated Watershed Development and Management Programme
IWDP	-	Integrated Waste Land Development Programme/ Integrated Watershed Development Project
IWMCFPR	-	Integrated Watershed Management in the Catchment of Flood Prone Rivers
IWT	-	Inland Water Transport

J

JGSY	-	Jawahar Gram Samrudhi Yojana
JRC	-	Joint Rivers Commission, Indo - Bangladesh
JRY	-	Jawahar Rojgar Yojana

K

K	-	Potassium
KBK	-	Kalahandi, Bolangir, Koraput
K.C.CANAL	-	Kurnool – Cuddapah Canal
KFW	-	Kreditanstant for Wiederaufbau
kg	-	Kilogram
kg / ha	-	Kilogram per hectare
Kl	-	Kilo Litre
km	-	Kilometre
km^2	-	Square Kilometre
km^3	-	Cubic Kilometre
KWDT	-	Krishna Water Disputes Tribunal
kWh	-	Kilo Watt hour

L

l	-	Litre
LIC	-	Life Insurance Corporation
LNWT	-	Low & Non Waste Technology
lpcd	-	Litres per Capita per Day
LPS	-	Litres per second

M

m	-	Metre
m^3	-	Cubic Metre
MAF	-	Million Acre Feet
Max.	-	Maximum
Mcft	-	Million Cubic Feet

Mcum or MCM or Mm^3	-	Million Cubic Metres
m^3/d	-	Cubic Metre per Day
MDPE	-	Medium Density Polyethelene
MEA	-	Ministry of External Affairs
MED	-	Multi Effect Distillation
mg	-	Milligram
MGD	-	Million Gallons per Day
mg/l	-	Milligram per Litre
Mha	-	Million Hectares
Mha m	-	Million Hectare Metres
Min.	-	Minimum
MINARS	-	Monitoring of Indian National Aquatic Resources System
MINAS	-	Minimal National Standards
MLD	-	Million Litres per Day
mm	-	Millimetre
MNES	-	Ministry of Non – Conventional Energy Sources
MOA	-	Ministry of Agriculture
MOD	-	Ministry of Defence
MOEF	-	Ministry of Environment & Forests
MOP	-	Ministry of Planning & Programme Implementation
MOU	-	Memorandum of Understanding
MOUAE	-	Ministry of Urban Affairs and Employment
MOWH	-	Ministry of Works and Housing
MOWR	-	Ministry of Water Resources
MPN	-	Most Probable Number
MRAE	-	Ministry of Rural Areas and Employment
MRL	-	Madras Refineries Limited
MSEB	-	Maharashtra State Electricity Board
m^3/sec	-	Cubic Metre per Second
MSF	-	Multistage Flash Distillation
MW	-	Mega Watt

N

N	-	Nitrogen
NA	-	Not Available
NABARD	-	National Bank for Agricultural and Rural Development
NC	-	Non Covered
NCA	-	Net Cropped Area

NCIWRDP	-	National Commission for Integrated Water Resources Development Plan
NCT	-	National Capital Territory
NCU	-	National Commission on Urbanisation
NDC	-	National Development Council
NDDB	-	National Dairy Development Board
NE	-	North East
NEEPC	-	North Eastern Electric Power Corporation
NEERI	-	National Environmental Engineering Research Institute
-ve	-	Negative
NGO	-	Non – Governmental Organisation
NHPC	-	National Hydro Electric Power Corporation Ltd.
NIA	-	Net Irrigated Area
NIR	-	Net Irrigation Requirement
NIUA	-	National Institute of Urban Affairs
NJPC	-	Naptha Jhakri Power Corporation
NLCP	-	National Lake Conservation Plan
NPC	-	National Productivity Council
NPL	-	Non-Physical Losses
NRCA	-	National River Conservation Authority
NRCP	-	National River Conservation Plan
NREP	-	National Rural Employment Programme
NRSA	-	National Remote Sensing Agency
NSA	-	Net Sown Area
NSS	-	National Sample Survey
NSSLUP	-	National Bureau of Soil Survey & Land Use Planning
NTPC	-	National Thermal Power Corporation
NTU	-	Neffier's Turbidity Units
NWB	-	National Water Board
NWDA	-	National Water Development Agency
NWDPRA	-	National Watershed Development Project in Rainfed Areas
NWDT	-	Narmada Water Disputes Tribunal
NWP	-	National Water Policy
NWRC	-	National Water Resources Council

O

ODA	-	Overseas Development Assistance
OECF	-	Overseas Economic Cooperative Fund (Japan)
OFD	-	On Farm Development
O & M	-	Operation and Maintenance
ONGC	-	Oil and Natural Gas Commission

P

P	-	Phosphorous
PAC	-	Public Accounts Committee
PAPs	-	Project Affected Persons
PAWDI	-	Peoples Action for Watershed Development Initiative
PCY	-	Per Capita Income Growth per Year
PERT	-	Planning Evaluation and Review Technique
PFC	-	Power Finance Corporation
PFR	-	Pre Feasibility Report
PIM	-	Participatory Irrigation Management
PL	-	Physical Losses
PMA	-	Phenyl Mercuric Acetate
POM	-	Plan of Operation and Maintenance
+ve	-	Positive
PPM	-	Parts per Million
PRI	-	Panchayat Raj Institute
PS	-	Pumped Storage
PSEB	-	Punjab State Electricity Board
PTW	-	Public Tube Well
PV	-	Problem Villages

R

RAJAD	-	Rajasthan Agricultural and Drainage Project
RBA	-	Rashtriya Barh Ayog
RBO	-	River Basin Organisation
R&D	-	Research & Development
RGI	-	Registrar General of India
RGNDWM	-	Rajiv Gandhi National Drinking Water Mission
RIDF	-	Rural Infrastructure Development Fund
RITES	-	Rail India Technical & Economic Services Ltd.
RKMLP	-	Ram Krishna Mission Lokasiksha Parishad
RLEGP	-	Rural Landless Employment Guarantee Programme

RM & U	-	Renovation, Modernisation & Uprating
RO	-	Reverse Osmosis
R&R	-	Resettlement & Rehabilitation
RSC	-	Residual Sodium Carbonate
RSEB	-	Rajasthan State Electricity Board
RWS	-	Rotational Water Supply

S

SAR	-	Sodium Absorption Ratio
SDC	-	Swiss Development Cooperation
SGWA	-	State Ground Water Authority
SPCB	-	State Pollution Control Board
SR	-	Service Reservoir
SSI	-	Small Scale Industries
SSP	-	Sardar Sarovar Project
STP	-	Sewage Treatment Plant
STW	-	Shallow Tube Well
SW	-	Surface Water

T

t	-	Tonne
TA	-	Tribal Area
TAC	-	Technical Advisory Committee
TBS	-	Tarun Bharat Sangh
TDS	-	Total Dissolved Salts / Total Dissolved Solids
TEC	-	Techno Economic Clearance
TERI	-	Tata Energy Research Institute
TES	-	Trade Effluent Surcharge
THDC	-	Tehri Hydro Power Development Corporation
TMC	-	Thousand Million Cubic Feet
TOR	-	Terms of Reference
TSS	-	Total Suspended Solids
TVA	-	Tennessee Valley Authority

U

UASB	-	Upflow Anaerobic Sludge Blanket
UCD	-	Urban Community Development
UFW	-	Unaccounted For Water
UIP	-	Ultimate Irrigation Potential
ULB	-	Urban Local Bodies
UN	-	United Nations

UNCED	-	United Nations Conference on Environment and Development
UNDP	-	United Nations Development Programme
UNEP	-	United Nations Environment Programme
UNICEF	-	United Nations Childrens' Fund
U/S	-	Upstream
USA	-	United State of America
USBR	-	United State Bureau of Reclamation
UT	-	Union Territory

V

VO	-	Voluntary Organization
VSAC	-	Village Service Area Committee

W

WAPCOS	-	Water & Power Consultancy Services (India) Ltd.
WARPO	-	Water Resources Planning Organisation, Bangladesh
WATSAN	-	Water and Sanitation
WDPSCA	-	Watershed Development Project for Control of Shifting Cultivation Areas
WG	-	Working Group
WHO	-	World Health Organisation
WMO	-	World Metereological Organisation
WQM	-	Water Quality Monitoring
WRCP	-	Water Resources Consolidation Project
WSP	-	Waste Stabilization Pond
WUA	-	Water Users' Association
WUE	-	Water Use Efficiency

Conversion Factors

LENGTH

1 Inch (in)	=	25.4 Millimetre (mm)
	=	2.54 Centimetre (cm)
1 cm	=	0.394 in
1 Metre (m)	=	3.281 Feet (ft)
1 ft	=	30.48 cm
1 Kilometre (km)	=	0.621 mile
1 mile	=	1.61 km

AREA

1 Square Metre (m^2)	=	10.764 Square Feet (ft^2)
1 ft^2	=	0.093 m^2
1 Hectare (ha)	=	2.47 Acre
	=	10,000 m^2
1 Acre	=	0.405 ha
	=	43,560 ft^2
1 Square Kilometre (km^2)	=	0.386 $mile^2$
	=	100 ha
1 $mile^2$	=	2.59 km^2
	=	259 ha
	=	640 Acres

VOLUME

1 Cubic Metre (m^3)	=	35.315 Cubic Feet (ft^3)
	=	1 kilolitre
	=	1000 litres
1 ft^3	=	0.0283 m^3
	=	28.32 litres
	=	6.23 UK Gallons
1 UK Gallon	=	4.546 litres
	=	0.1605 ft^3
1 Acre Feet (Acre ft)	=	1233.48 m^3
1 m^3	=	0.00081 Acre ft
1 Hectare Metre (ha m)	=	8.10 Acre ft
	=	10,000 m^3
1 Acre ft	=	0.1233 ha m
	=	43,560 ft^3
1 Million Cubic Metre (Mm^3)	=	810.71 Acre ft
1 Million Acre Feet (MAF)	=	1233.48 Mm^3
1 Mm^3	=	0.00081 MAF
1 Million Cubic Feet (Mft^3)	=	0.0283 Mm^3
1 Mm^3	=	35.315 Mft^3
1 Thousand Million Cubic Feet (TMC)	=	28.317 Mm^3
	=	22956.87 Acre ft
1 Mm^3	=	0.0353 TMC
1 Cubic Kilometre(km^3)	=	1 Billion Cubic Metre (BCM)
	=	0.81 MAF
	=	10^9 m^3
	=	1 milliard m^3
	=	0.10 Million ha m
1 MAF	=	1.233 km^3 or BCM
	=	43.56 TMC

DISCHARGE

1 Cubic Metre per second (m^3/sec)	=	35.315 Cubic Feet per second (ft^3/sec)
	=	1000 litres/sec
1 ft^3/sec	=	0.0283 m^3/sec
1 ft^3/sec per day	=	1.984 Acre ft per day
1 Million Gallons per day	=	1.858 ft^3/sec

VELOCITY

1 Metre per second (m/sec)	=	3.281 Feet per second (ft / sec)
1 ft / sec	=	0.3048 m/sec
1 Kilometre per hour (km/hr)	=	0.621 Mile per hour (mph)
1 mph	=	1.61 km / hr

WEIGHT

1 Gram (g)	=	1000 Milligrams (mg)
1 Kilogram (kg)	=	1000 g
	=	2.205 Pounds (lb)
1 lb	=	0.454 kg
1 Tonne (t)	=	0.9842 Tons
	=	1000 kg
1 Ton	=	1.016 tonne
	=	1016 kg
	=	2240 lb

ENERGY

1 Kilowatt hour (kWh)	=	1.341 Horse Power hour (hph)
	=	3.6 X 10^6 Joules (J)
	=	859.85 kilocalories (kcal)
1 J	=	2.778 X 10^{-7} kWh
1 kcal	=	1000 calories
	=	0.001163 kWh
	=	4186.8 J
1 hph	=	0.746 kWh
	=	2544.43 British Thermal Units(Btu)
1 Btu	=	1055.06 J
1 Gegawatt hour (GWh)	=	10^6 kWh
	=	10^3 Megawatt hour (MWh)

POWER

1 Horse Power (hp)	=	0.746 kW
	=	550 ftlb/sec
1 Kilowatt (kW)	=	1000 Watts (W)
1 Mega Watt (MW)	=	1000 kW
1 Gega Watt (GW)	=	1000 MW

DENSITY

1 Gram per Cubic Centimetre (g/cm^3)	=	1000 Kilograms per Cubic Metres (kg/m^3)
	=	0.0361 Pound per Cubic Inch(lb/in^3)
1 lb / in^3	=	27.7 g / cm^3
1 Tonne per Cubic Metre (t/m^3)	=	0.0361 lb / in^3
1 lb / in^3	=	27.7 t / m^3

TEMPERATURE

1 Fahrenheit (°F)	=	1.8°C + 32
1 Celsius (°C)	=	0.56 (°F – 32)
1 Kelvin (°K)	=	°C + 273.15
	=	0.56 (°F + 459.67)
1 °C	=	°K – 273.15
1 °F	=	1.8 °K – 459.67

CHAPTER - 1

INTRODUCTION

Water is a basic human need and a prime natural resource. While the endowment of water resources in the country may appear abundant, there are great variations in the availability of fresh water over space(that is, between different parts of the country) and over time (that is, between different periods in the year). The pressure on the availability of usable water is also mounting because of the finite nature of the supply and the ever-increasing demand on it by a growing population aspiring to higher standards of living. Maximizing the availability of utilisable water with due regard to harmony with nature and environmental sustainability, taking an integrated view of water in all its forms, balancing the water demands for different purposes, keeping national perspectives in view and meeting the needs of water-short areas in the country, optimizing benefits and bringing about a more even and equitable distribution of those benefits, and ensuring the economical use and due conservation of this increasingly scarce resource, are among the objectives that need to be kept in mind in integrated water resource planning.

1.1 Constitution of the National Commission

To achieve the aforesaid objectives, the Government of India, Ministry of Water Resources constituted a ten member High Powered Commission, for preparation of an Integrated Water Resources Development Plan, under the Chairmanship of Dr.G.V.K. Rao, former Member, Planning Commission vide MOWR Office Memorandum No.2/11/96-BM/654 dated 13th September, 1996 (Annexure-1.1). Six additional members were co-opted between October, 1996 and December, 1997 and the Director General, NWDA was designated as the Member-Secretary. The Commission was subsequently renamed as "National Commission for Integrated Water Resources Development Plan". Meanwhile, Dr. G.V.K. Rao resigned as Chairman of the Commission due to reasons of health. Prof. C.H. Hanumantha Rao, former Member, Planning Commission was appointed as Chairman, in place of Dr. G.V.K. Rao in November, 1996, but due to other commitments, Prof. Hanumantha Rao expressed his inability to join the Commission. In February, 1997, Dr. S.R. Hashim was appointed as Chairman, and the work of the Commission could begin only thereafter. Dr. A. Vaidyanathan, one of the co-opted members, resigned due to his pre-occupation with other work. Shri S.P. Caprihan was not able to take part in the deliberations of the Commission since November, 1998, owing to continued ill-health. Shri Arun Kumar, Additional Secretary in the Ministry of Water Resources was associated with the Commission as a member from the inception, until a few months before the completion of its work when his place was taken by Shri P. Mohandas as Additional Secretary in the Ministry of Water Resources.

1.2 Composition of the National Commission

The composition of the National Commission is as follows:

1.	Dr. S.R. Hashim,Member,Planning Commission, Govt. of India	.. ..	Chairman
2.	Shri V. Ramachandran, Former Chief Secretary to Government and Vice-Chairman, State Planning Board, Kerala	.. ..	Member

3.	Prof. V.S. Vyas, Former Director, Institute of Development Studies,Jaipur	.. ..	Member
4.	Dr. D.N. Tewari,Member,Planning Commission, Govt. of India	.. ..	Member
5.	Shri S. Prakash,Former Engineer-in-Chief, Delhi Water Supply & Sewage Disposal Undertaking	.. ..	Member
6.	Dr. C.C. Patel,Former Secretary to Government of India for Water Resources	.. ..	Member
7.	Dr. Bharat Singh,Former Vice-Chancellor, University of Roorkee	.. ..	Member
8.	Shri S.P. Caprihan, Former Engineer-in-Chief, Government of Madhya Pradesh	.. ..	Member
9.	Shri Ramaswamy R. Iyer,Former Secretary to the Govt. of India for Water Resources and Research Professor, Centre for Policy Research,New Delhi.	.. ..	Member
10.	Shri B.G. Verghese,Eminent Columnist and Research Professor, Centre for Policy Research,New Delhi	.. ..	Member
11.	Shri P.Mohandas,Additional Secretary, Ministry of Water Resources,Govt. of India.	.. ..	Member
12.	Shri A.D.Mohile,Chairman, Central Water Commission	.. ..	Member
13.	Dr. D.K.Chadha,Chairman, Central Ground Water Board	.. ..	Member
14.	Shri R.K.Parashar,Director General, National Water Development Agency	.. ..	Member-Secretary

Shri Z. Hasan, Secretary, Ministry of Water Resources, Dr. C.D.Thatte, former Secretary, Ministry of Water Resources and Shri B.N. Navalawala, Advisor, Planning Commission are permanent invitees.

The National Water Development Agency was entrusted with the task of providing secretarial assistance to the Commission. During the term of the Commission, Shri A.D.Mohile, Shri Z.Hasan, Dr.B.K. Mittal and Shri R.K.Parashar were Director General, National Water Development Agency for different periods and served as Member-Secretary to the Commission.

1.3 Terms of Reference of the Commission

The terms of reference of the National Commission are as follows:

- (a) To prepare an Integrated Water Plan for development of water resources for drinking, irrigation, industrial, flood control and other uses;
- (b) To suggest modalities for transfer of surplus water to water deficit basins by interlinking of rivers for achieving the above objectives;
- (c) To identify important ongoing projects as well as new projects which should be completed on priority basis together with phasing;
- (d) To identify a technological and interdisciplinary research plan for the water sector with a view to maximise the benefits;
- (e) To suggest physical and financial resource generation strategies for the water sector; and
- (f) Any other related issue.

1.4 Task Force & Core Working Group

In order to initiate the preparatory work and to suggest the method of work and the necessary administrative arrangements, a Task Force under the Chairmanship of Dr. S.R. Hashim was constituted early in October, 1996. As recommended by the Task Force, the Commission at its first meeting decided to deal with its task through broad-based Working Groups, instead of through an enlarged secretariat. It constituted a Core Working Group in place of the Task Force, to examine and make recommendations as regards the following:

- To suggest in detail the work plan considering the terms of reference of the National Commission;
- Make suggestions about Working Groups;
- Make suggestions about overall coordination of the work; and
- Examine and recommend the secretariat requirements for the National Commission.

The Core Working Group was headed by the Chairman of the Commission and consisted of five other members in addition to the Member Secretary, namely Prof. V.S.Vyas, Sri Ramaswamy R.Iyer, Sri B.G. Verghese and the Secretary and Additional Secretary to the Ministry of Water Resources. After a series of meetings, the Core Working Group suggested the details of the Working Groups and their terms of reference.

1.5 Working Groups

As recommended by the Core Group, nine Working Groups were formed under the Chairmanship of different members of the Commission to deal with specific fields related to the terms of reference. The list of the Working Groups so constituted along with the name of the Chairman of each Group is given below:

Sl.No.	Name of Working Group	Chairman
1	Perspective of water requirements	Dr. V.S. Vyas
2	Water availability for use	Dr. S.R. Hashim

Sl.No.	Name of Working Group	Chairman
3	Water management for agriculture, hydropower, flood control and other allied sectors	Dr. C.C. Patel
4	Water management for domestic, industrial and other uses	Shri S. Prakash
5	Legal, institutional and financing aspects	Shri V. Ramachandran
6	Environmental aspects	Dr.D.N. Tewari
7	Interbasin transfer of water	Dr. Bharat Singh
8	Prioritisation of ongoing and new projects together with phasing	Shri S.P. Caprihan (upto 23-10-1998) & Shri A.D. Mohile
9	International dimensions of water planning	Shri B.G. Verghese

The composition and the terms of reference of each of the Working Groups are furnished in Annexures-1.2 and 1.3 respectively. While setting up the various Working Groups, adequate care was taken to ensure that knowledgeable and experienced persons were drawn from various disciplines, namely engineering, sciences, economics, sociology, environment and other interests in order to obtain views and advice from a variety of sources. It was envisaged to avail of the services of a full time consultant for each Working Group, who acted as " Resource Person " for the Group and assisted the Chairman of Working Group. To deal with the wide range of terms of reference of the Working Group on " Water Management for Agriculture, Hydropower, Flood Control and Other Allied Sectors ", eight Sub-Groups were formed for this Working Group to collect data, information, maps and prepare reports on various terms of reference which are grouped together on the basis of similarity in contents. The composition of the Sub-Groups is given in Annexure-1.4. In order to obtain specific expertise concerning certain issues, five consultants were also engaged for short periods. The list of officers of the Secretariat of the National Commission is given in Annexure -1.5.

In all, 76 meetings were held by the various Working Groups and 13 meetings by the various Sub-Groups. The Groups worked diligently for over two years and each of them has prepared a detailed Report on its theme with elaborate data and a number of Tables and annexures. The Working Groups' reports, at different stages of preparation, formed the basis for the Commission's deliberations in its sittings.

1.6 Consultation with Policy Makers, Officials, Public Leaders and Professionals

The process of consultation with all concerned, including State Governments, continued throughout the work of the Commission and a constant feed back of views and advice was obtained. This was achieved

- through correspondence with a large number of eminent persons before deciding upon the detailed terms of reference and composition of the Working Groups;
- by circulating a questionnaire to State Governments/ Union Territories /Experts/ Academic Institutions etc. to solicit their views on various aspects of water resources development;
- by carefully choosing the members of the Working Groups to cover a wide range of expertise, experience and interests;
- by informal consultations by the members of the Working Groups with others including serving and retired officials;

- by conducting four Regional Seminars. The Seminars, in particular, provided a suitable platform for active participation of legislators, ministers, bureaucrats, professionals, water users, NGOs and activists;
- by participation of members of the National Commission and Working Groups in the Seventh National Water Convention held at Lucknow during January, 1998; and
- by getting nodal officers identified in each State and Union Territory as well as Central Ministries and Government Departments, in order to have continuous interaction to obtain relevant data, information and feed back.

1.7 Seminars

With a view to benefiting from the views, opinions and responses of a wide range of experts, policy planners, opinion makers and thinkers from all over the country, the National Commission conducted four Regional Seminars, one each at Ahmedabad, Bangalore, Calcutta & Delhi, on the theme "Water Resources Development Plan – Policy & Issues". Participants in these Seminars included representatives from Central Government, Governments of States and Union Territories, academics from Universities and Institutes, NGOs as well as well known experts and social thinkers having interest in water resource planning and development.

The first Regional Seminar was held on 28-29 January, 1999 at Ahmedabad. The Seminar was inaugurated by Shri Keshubhai Patel, Chief Minister of Gujarat. Shri Nitinbhai Patel, Minister for Agriculture, Medium & Minor Irrigation Projects and Shri Jayanarayan Vyas, Minister for Narmada & Major Irrigation Projects of Gujarat State also addressed the delegates during the inaugural function. Prof. Y.K. Alagh, Member of Parliament and Former Minister of State, Government of India delivered the valedictory address. Shri Sanatbhai Mehta, Former Member of Parliament and Former Chairman, Sardar Sarovar Narmada Nigam Ltd.(SSNNL), Gujarat participated in the Seminar. Senior officers from the States of Gujarat, Maharashtra, Rajasthan, Madhya Pradesh and the Union Territory of Dadra & Nagar Haveli, eminent water resource experts, management experts, educationists, journalists, sociologists, economists and NGOs actively participated in the Seminar.

The second Regional Seminar was held at Bangalore on 15-16 February, 1999. The Seminar was inaugurated by Shri K.N. Nage Gowda, Minister for Major & Medium Irrigation, Karnataka. Shri Durai Murugan, Minister for Public Works, Tamil Nadu delivered the valedictory address. Shri Z. Hasan, Secretary, Ministry of Water Resources, Government of India also attended the Seminar. Senior officers from Governments of Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Goa and Union Territories of Pondicherry and Lakshadweep, eminent water resource experts, distinguished economists, sociologists, NGOs and a Supreme Court Lawyer actively participated in the Seminar.

The third Regional Seminar was held at Calcutta on 25-26 February, 1999. Shri Debabrata Bandyopadhyay, Minister, Irrigation & Waterways Department, Government of West Bengal inaugurated the Seminar and Shri Nanda Gopal Bhattacharjee, Minister, Water Investigation & Development Department, Government of West Bengal presided over the inauguration ceremony. Shri Abdul Muhib Mazumdar,Minister, Irrigation Department, Government of Assam delivered the valedictory address. Senior officers from State Governments of West Bengal, Bihar, Orissa, Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, Sikkim and Union Territory of Andaman & Nicobar, eminent water resource experts, distinguished economists, sociologists and NGOs actively participated in the Seminar.

The fourth Regional Seminar was held on 19-20 March, 1999 in New Delhi. The Seminar was inaugurated by Shri Sompal, Union Minister of State for Agriculture & Water Resources, Government of

India. Shri Harsh Kumar, Minister of State for Irrigation, Government of Haryana was the Guest of Honour. Two Members of Parliament from Jammu & Kashmir State were also present during the inaugural function. Senior officers from the Governments of Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh and Union Territories of Delhi & Chandigarh, eminent water resource experts, distinguished economists, sociologists, NGOs and a Supreme Court Lawyer actively participated in the Seminar. Representatives of Central Ministries/ Government Departments connected with water sector also participated in the Seminar.

In all, 414 persons connected with and having interest in the subject participated in the four Seminars. All the Seminars were highly successful in fulfilling the objective of providing inputs to the Commission from concerned persons in different fields invited from all parts of the country. A number of important criticisms and suggestions were made during the deliberations in the Seminars which included improving water availability and supplies, demands of water, water planning and management, institutional and legal aspects, ground water abstraction, water pricing, domestic water supply, industrial water use, navigation, interbasin/intrabasin transfer, flood management, environmental problems, policy issues, international issues and other relevant issues affecting the water sector as a whole.

1.8 Report

As stated earlier, a major part of the work was done through Working Groups headed by the members. The full Commission met in 21 sessions spread over 41 days. At two of its meetings, the Commission had the benefit of discussion with Shri Sompal, Minister of State for Agriculture and Water Resources and Prof.Y.K. Alagh, then Minister of State for Planning and Science and Technology. Though, as stated earlier, the data collected by the Working Groups, the discussions in their meetings and the draft reports formed the basic material for the Commission's deliberations, the conclusions and recommendations presented in this Report are those of the full Commission and are not necessarily the same as those of the Working Groups.

We have presented in our Report a framework of action plan for policy formulation, legal and institutional set up, financial planning and prioritisation of projects for integrated development and augmentation of utilisable water resources, taking care of the human, social, regional and environmental concerns. We believe strongly that we would be able to move in the direction of that objective to the extent that the suggested action plan is implemented during the next three to five years. We have not prepared a Plan in the sense of a suggested outlay over a period of time on a list of projects, as it would be unrealistic to do so at this stage.

The Report of the National Commission is presented in two volumes. Volume-I contains the main report grouped into fifteen chapters and Volume-II contains the maps.
The fifteen chapters of Volume I are:

1. Introduction
2. Water: An Overview – Issues and concerns
3. Water Availability and Requirements
4. Development and Management Issues: Irrigation, Flood Control, Hydropower and Navigation
5. Development and Management Issues: Domestic, Industrial and Other Uses
6. Local Water Resources Development and Management
7. Interbasin Transfers
8. Legal and Institutional Framework

9. Economic and Financial Management
10. Project Planning and Prioritisation
11. International Dimensions
12. Water Quality and Environmental Aspects
13. Research and Development Needs
14. Towards Sustainable Development
15. Summary of Recommendations

Volume-II of the report contains ten national maps and nine river basin maps. Except for the national map depicting surface water resources, which has been prepared in four maps on a scale of 1 : 12 million, all other national maps have been prepared on a scale of 1 : 6 million and present the physiography, soil classification, land use, agro-ecological regions, surface water quality, ground water resources, major water resources projects, states and river basins and proposed interbasin water transfer links. The river basin maps are prepared on a scale of 1 : 2 million. These maps, for the first time, present the submergence area and command area of major projects in different river basins. The Volume on maps has been prepared by the National Atlas and Thematic Mapping Organisation, Calcutta at the instance of the Commission and under the guidance of some of the members and Dr. C.D.Thatte.

The reports of nine Working Groups and eight Sub-Groups of the Working Group on " Water Management for Agriculture, Hydropower, Flood Control and Other Allied Sectors" are printed and presented separately and will be particularly useful to the Central Water Commission and the Ministries, the Planning Commission, the State Governments, research institutions and scholars.

1.9 Acknowledgement

As will be clear from the method of work adopted by the Commission, we owe a debt of gratitude to literally scores of persons and it is difficult to name them all individually.

We wish to place on record our gratefulness and high appreciation of the hard work done by the members of the Working Groups and Sub-Groups and the Resource Persons. It was really a gigantic task to collect, analyse and interpret the large amount of data and material for consideration by the Commission and preparation of the Reports. Each of the Working Groups has attended to this stupendous task with exemplary thoroughness, professionalism and promptitude.

We would like to express our deep gratitude to various Ministries of Government of India and the State Governments who extended full cooperation and readily supplied the information and data requested from them.

We received throughout our working, the full cooperation and support of the Ministry of Water Resources and the Central Water Commission. Successive Secretaries to the Government of India, Shri Mata Prasad and Shri Z. Hasan; Shri Arun Kumar, as Additional Secretary; Shri Ramesh Chandra and Shri Z.Hasan as Chairmen, CWC, took personal interest in the work of the Commission and helped us in every possible way.

The Commission also wishes to acknowledge the cooperation and assistance rendered by the Central Ground Water Board, Water and Power Consultancy Services(India) Ltd., National Water Development Agency, Central Electricity Authority, National Atlas and Thematic Mapping Organisation, Survey of India. National Bureau of Soil Sciences & Land Use Planning, Indian Agricultural Research Institute, Geological Survey of India, Sardar Patel Institute of Economic and Social Research, Ahmedabad; Indian Institute of Management, Calcutta; Institute for Social & Economic Change, Bangalore and Central Soil & Materials Research Station, New Delhi.

The Commission is thankful to everyone of the participants in the Regional Seminars and to all those who took pains to send their views in writing.

The successive Director Generals of NWDA and the officers and staff of the Commission's Secretariat deserve a special mention for the readiness, cheerfulness and dedication with which they attended to every demand of the Commission and its Working Groups and provided the secretarial assistance in addition to their regular duties.

S. R. Hashim

(S.R. Hashim)
Chairman

Members

(V. Ramachandran)

V. S. Vyas

(V.S. Vyas)

(D.N. Tewari)

S. Prakash

(S. Prakash)

(C.C. Patel)

(D.K. Chadha)

Members

Bharat Singh

(Bharat Singh)

(Ramaswamy R. Iyer)*

(B.G. Verghese)

(P. Mohandas)

(A.D. Mohile)

(R.K. Parashar)
Member-Secretary

* Please see my separate note

CHAPTER - 2

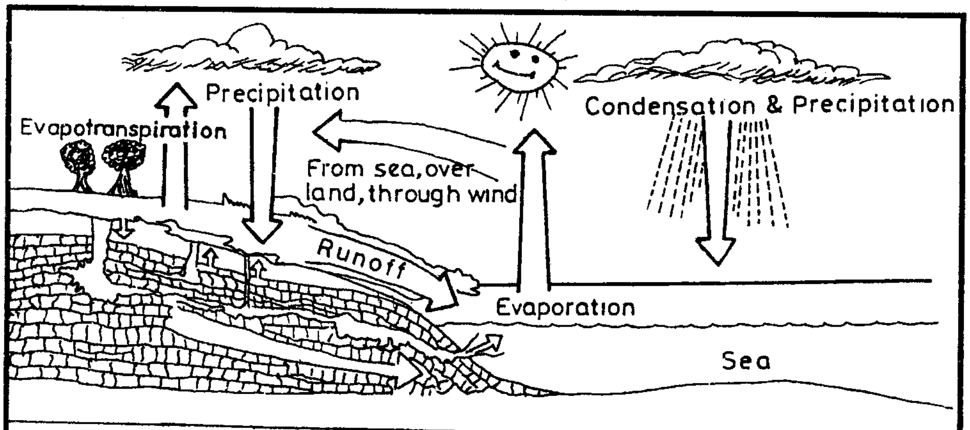
WATER: AN OVERVIEW - ISSUES AND CONCERNS

While there have been Commissions on agriculture, irrigation and floods earlier, this is the first National Commission on water resources. We have tried to keep this significant fact constantly in mind during our deliberations. This Report will no doubt deal with issues relating to agriculture, irrigation, hydro-electric power, and so on; but its primary concern will be with water as a natural resource. Before going into sectoral and sub-sectoral details, it may be useful to pause at the threshold and take a preliminary look at the scene. This chapter first provides an overview of the water situation from global and national perspectives; it then presents, in broad outline, the issues and concerns that demand attention. It concludes with some remarks on the need for a review of the National Water Policy.

2.1 Water: An Overview

It is hard to believe that this earth in which water seems to be the dominant element should ever face a shortage of water. According to UN estimates, the total amount of water on earth is around 1,400 million km^3 , which is enough to cover the earth with a water layer of a depth of 3,000 metres. However, oceans cover about three-fourths of the earth's surface and nearly 98 percent of earth's water is in the oceans and seas. Fresh water constitutes a very small proportion (2.7 percent) of the total quantity of water available on earth. Of this, 75.2 percent lies frozen in polar regions and a further 22.6 percent is present as groundwater, of which again a part lies too far underground to be used. Fortunately, a tiny fraction of the planet's water is renewed and made fresh by nature's solar-powered water cycle. This is available in lakes, rivers, atmosphere, moisture, soil and vegetation. What is effectively available for consumption and other uses is a small proportion of the quantity present in rivers, lakes and underground aquifers.

In the operation of the annual hydrological cycle (See diagram below), it has been estimated that 4,00,000 km^3 of water are taken up by way of evaporation of which 3,40,000 km^3 are taken from the sea and about 60,000 km^3 from land. The amount returned to earth as precipitation in the form of rain, hail, snow or others is estimated as 3,00,000 km^3 over the seas and 1,00,000 km^3 over land. This results in an average annual flow of 40,000 Km^3 from the land to the sea. This is what can be termed as the world's renewable fresh water supply.



SIMPLE DIAGRAM OF HYDROLOGIC CYCLE

This supply of water should be juxtaposed against the ever increasing world population, currently estimated to be around six billion, and likely to rise to over eight billion by the year 2050. All the waters flowing in the rivers are not available for beneficial use. Moreover, there are extreme variations in the availability of water over space and time, and they do not necessarily match the variations in human needs. This further restricts the availability of water for beneficial uses.

At the end of the twentieth century, the world faces a number of challenges affecting the availability, accessibility, use and sustainability of its fresh water resources. These could have serious implications for present and future generations of humanity as also for natural ecosystems.

2.2 The Global Scene

The use of water in the world has increased by more than 35 times over the past three centuries. Globally 3,240 Km^3 of fresh water are withdrawn and used annually. Of this total, 69 percent is used for agriculture, 23 percent for industry and eight percent for domestic use. Water use varies considerably around the world. In Africa, Asia and South America, agriculture is the primary user. Asia uses 86 percent of its water for agriculture, mainly through irrigation, but in most of Europe and North America, domestic and industrial requirements of water exceed agricultural needs.

Even though fresh water is a renewable resource, it is also a finite resource. This means that the supply per head, a broad indicator of water availability, drops as the population grows. It is clear that water is going to become one of the most sought-after resources in the next century. For obvious reasons, the population pressure will be greater in the developing world than in the advanced nations. Besides, the pace of industrialization and urbanization is adding another dimension to the scarcity.

Clear and wholesome water is a scarce resource, essential for life but so often taken for granted. Managing the water cycle for the benefit of mankind and the environment is one of today's greatest challenges. One of the clear signals of water scarcity is the increasing number of countries in which the population has surpassed the level that can be sustained comfortably by the available water. In 1989 expert studies (Falkenmark et al., 1989) ranked countries according to per capita annual water resources (AWR) in each country. They classified countries with an AWR per capita of 1,700 m^3 and above as those where the shortage will be local and rare; those with an AWR of less than 1,000 m^3 (which hampers wellbeing, economic development and the protection of natural systems) as water-stressed countries; and those with an AWR of 500 m^3 and below as countries where water availability is a primary constraint to life. Only seven countries faced water-stressed conditions in 1955. The number rose to 20 in 1990 and 10-15 more countries will be added to the list by the year 2025. Two-thirds of the world's population might face the water-stressed condition by 2050.

At present global per capita availability of both, surface and ground water is about 7,000 m^3 per year. However, much of this quantum is available during short spells of rainy seasons due to variability of precipitation in space and time. The AWR, therefore, cannot be put to beneficial use unless held back from flowing waste to the seas. In countries with tropical monsoon type climate, as run of the river in fair weather is low, storages become critical in raising availability all through the year.

Unfortunately, water availability has not received the attention it deserves in global discussions of the sustainable use of natural resources. It has been examined even less in the context of population growth. More than three-fourths of the surface of the planet being covered by water, the illusion of abundance has clouded the reality that renewable fresh water is an increasingly scarce resource. Our capacity for capturing and storing fresh water has expanded throughout history and we are learning how to use it more efficiently. However, no technology can significantly expand the basic resource. The possibility of desalination may seem to suggest that the world's oceans are potentially inexhaustible sources of fresh water, but the process of extracting salt from sea water is expensive and dependent on polluting and non-renewable fossil fuels. The reality is that there is essentially no more fresh water on the planet today than there was 2,000 years ago when the earth's human population was less than three percent its present magnitude of six billion. However, predicted changes in global climate could redistribute or affect water availability and increase the intensity of storms, adding to the challenges of the management of water resources.

Efforts to encourage water-conservation face special challenges not encountered in the case of other natural resources. In the major part of the world, water is not controlled by market mechanisms, nor is water a commodity that can be traded internationally like food or other merchandise. Whether people save or waste water in one region is of no material consequence to those who live in other regions. People need sources of clean water close to their homes.

2.3 Water Resources of India

Physical and Geographical Features

India's topography comprises towering mountain ranges, rolling hills, lofty plateaux and extensive plains traversed by major rivers. Bounded by the Himalayas in the north, India stretches southwards and tapers towards the Indian Ocean, with the Bay of Bengal in the east and the Arabian Sea in the west. India has a land frontier of over 15,000 km and a coastline of over 6,000 km, and is the seventh largest and second most populated country in the world.

The mountains of India are the sources of its streams and rivers which drain the waters received from rain and snowmelt. They affect its climate and rainfall. The major mountain ranges are the Himalayas, the Aravallis, the Vindhyas, the Satpuras, the Eastern and Western Ghats and the north-eastern ranges. The forests of India cover 63.34 Mha out of its total geographical area of 329 Mha, representing 19.25 percent of the area.

Plateaux are a prominent feature of Indian topography. They range in elevation from 300 to 900 metres and their flanks are often steep. The noteworthy plateaux are the Malwa, the Vindhya, the Chota Nagpur, the Satpura, the Deccan, Ladakh and Meghalaya.

The plains constitute the large part of the sub-continent. They include the Indo-Gangetic plains, the coastal alluvial and lava plains, the mountain plains, the Kashmir valley, the Imphal basin and Ladakh, the Piedmont plains at the Himalayan foothills, the pediplains of South India and peneplains of the Shillong plateau and the Nilgiris.

The climate of India is greatly influenced by the presence of the great mountain mass of the high Himalayas in the north and the ocean in the south. The sub-continent experiences both tropical and oceanic climates, ranging from extreme heat to extreme cold, from aridity and negligible rainfall to excessive humidity and torrential rainfall. The climatic conditions influence to a great extent the distribution of the water resources of the country.

The rainfall in the country depends on the southwest, retreat and northeast monsoons, shallow depressions and disturbances, violent local storms and occasional cyclones. Most of the rainfall in India occurs as a result of the southwest monsoon between June and September, except in the State of Tamil Nadu which falls under the influence of the retreat and northeast monsoon during October and November. Rainfall patterns vary greatly depending on the season and the region.

All India average rainfall is 1,170 mm, but it varies respectively from 100 to 11,000 mm in Western deserts to North Eastern region. More than 50 percent of precipitation takes place in about 15 days and less than 100 hours altogether in a year. The rainy days may be only about five in deserts to 150 in the North East.

Considering the rainfall, water availability and agro-economic conditions, the Planning Commission (Approach Paper to the Ninth Plan), while emphasising the need for regionally differentiated strategy of agricultural development, suggested the following classification of regions in the country:

- High Productivity Region: Relatively high productivity areas having either well developed irrigation system with moderate rainfall (north-western region of Punjab, Haryana and Western U.P) or very high assured rainfall(the coastal plains).

- Water Abundant Low Productivity Region: Relatively high rainfall areas with abundant surface and ground water availability, but relatively low irrigation development and low productivity in agriculture (Middle and Lower Gangetic plains, Eastern M.P and North-Eastern Region).

- Water Scarce Low Productivity Region: Low surface and ground water availability, and moderate agricultural productivity (The Peninsular India and Eastern Rajasthan and Gujarat).

- Ecologically Fragile Regions: The Himalayan slopes and desert areas of Rajasthan.

Surface Water

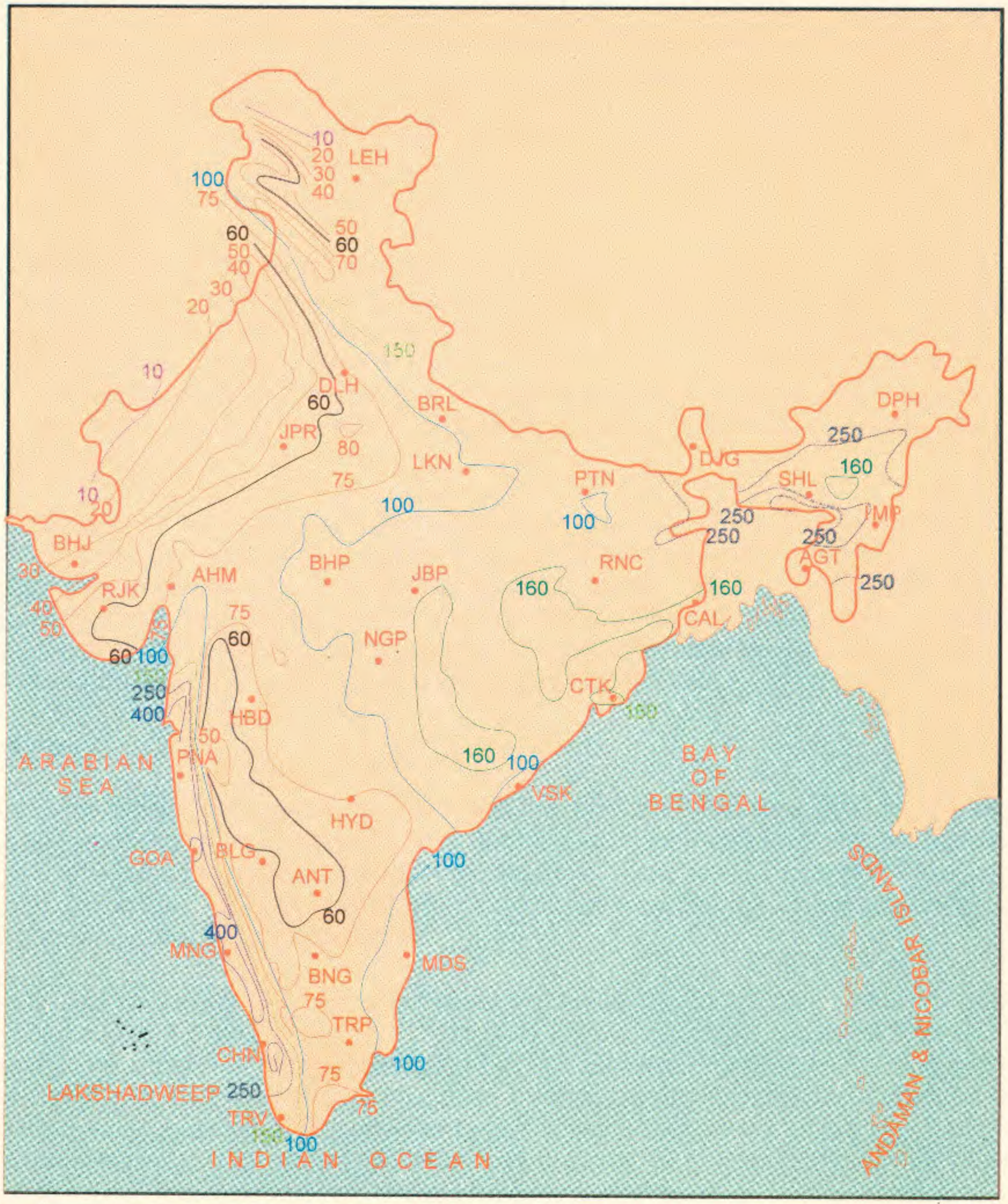
The average annual precipitation in India including snowfall has been estimated as 4,000 km^3. We have estimated the total annual water resources of the country (including both surface water and ground water) as 1,953 km^3. Some of this originates beyond our borders, and in turn some of it crosses our borders on its way to the sea and goes into downstream countries.

India, which has 2.45 percent of the world's land resources, has roughly four percent of the world's fresh water resources, whereas the country's population is 16 percent of the world's population.

The average annual rainfall Isohytes are given in Fig 2.1. However, 12 percent of the country receives an average rainfall of less than 610 mm annually and only eight percent receives more than 2,500 mm. Cherrapunji in the eastern part of Meghalaya receives 11,000 mm of rainfall while western Rajasthan receives only 100 mm. The variability of the rainfall from month to month and year to year for the same place is also very high, and increases in reverse relation to the total rainfall. Even low rainfall areas, especially in some parts of Gujarat and Rajasthan, are prone to occasional high-intensity storms.

More than 90 percent of the annual runoff in peninsular rivers and more than 80 percent of the annual runoff in Himalayan rivers occur during months of June to September. The Ganga-Brahmaputra- Meghna system is a major contributor to India's water resources representing more than 60 percent of the total. Many of the small rivers totally dry up during the summer. The depletion of forests has further aggravated the problem. Reduced infiltration results in smaller dry weather flows. Heavy silt concentration has resulted in deposition of silt in the flood plains since the shrinking river channels cannot transport excessive silt loads. This again reduces the valley storage which used to

FIG 2.1: NORMAL ANNUAL RAINFALL ISOHYETS



(i) BASED UPON SURVEY OF INDIA MAP WITH THE PERMISSION OF THE SURVEYOR GENERAL OF INDIA

(iii) THE TERRITORIAL WATERS OF INDIA EXTEND INTO THE SEA TO A DISTANCE OF TWELVE NAUTICAL MILES MEASURED FROM THE APPROPRIATE BASE LINE.

(iv) THE RESPONSIBILITY FOR CORRECTNESS OF INTERNAL DETAIL RESTS WITH THE PUBLISHER

SOURCE : "WATER MANAGEMENT PERSPECTIVE -1990", INDIAN NATIONAL ACADEMY OF ENGINEERING.

absorb high floods, resulting in higher flood peaks. About 40 million hectares are prone to floods, though not all the vulnerable areas get affected each year. Flood damage is on the increase with increasing occupation of flood plains and cultivation and developments thereon. On the other hand, about one-third of the country is afflicted by recurring droughts. Earlier 150 districts had been identified as drought-prone. As many as 71 districts in 9 States continue to suffer severe drought even after considerable irrigation development. The impact of droughts is even more severe than that of floods and leaves a permanent imprint on the economy and morale of the people. Drought has also aggravated regional imbalances in economic development.

The vulnerability of certain regions within the country to water scarcity is well illustrated by the case of Rajasthan. Situated in one of the most inhospitable arid zones in the world, Rajasthan's northwest corner extends into the vast Thar Desert. With a wide range of temperatures and an unpredictable monsoon climate, drought and desertification are common and water is a scarce commodity. With eight percent of India's population, Rajasthan has only one percent of the country's water resources, which come in the form of groundwater, limited rainfall, and a small share of waters that straddle state boundaries.

Even those who live in areas of high rainfall often face drought because landscapes have been denuded. Soil is compacted and most rainfall runs off before it can sink into the ground, increasing flooding. The region of Cherrapunji in Meghalaya, for example, receives the highest level of mean rainfall recorded in the world; and yet because of heavy seasonal rainfall and the nature of the topography, much of the runoff cannot be retained. The region now suffers from excessive flooding for three or four months and frequent droughts during the rest of the year.

Ground Water

Part of the precipitation percolates down into the earth and replenishes the groundwater in the aquifers. Just as surface water is stored in form of tanks, reservoirs and water bodies within the river or drainage channels, groundwater is stored in the aquifers. There are complex inter-linkages between surface water and groundwater. A part of the groundwater may emerge as surface water, and river flows may percolate down as groundwater.

The annual availability of groundwater is determined by the annual recharge of the aquifer (and further recharges over a period of say 3 to 5 years). It follows that water extracted from an aquifer in any year should be capable of being replenished through recharge from the succeeding precipitations (or other recharge), so that over a cycle of 2, 3 or 5 years, the groundwater table does not go down. When there is over-exploitation of groundwater (which is technically known as mining), the water table goes down progressively. Such over-exploitation has occurred at several places in our country, and has caused ingress of saline waters from the sea in some coastal areas.

There are very large aquifers especially in the Ganga and Brahmaputra basins, which have not been exploited fully upto their recharge potential. However, the feasibility and economics of fuller utilization of groundwater in these reaches requires further studies including that of the environmental impact of lowering groundwater levels. There are very large tracts in the peninsular region which are covered with hard rock at shallow depths. These areas have limited potential for groundwater and the availability is subject to rainfall during the year.

The quantum of dynamic groundwater which can be annually extracted economically is generally reckoned as the `groundwater potential' of the country. The total groundwater potential is assessed as 432 km^3. The Central Ground Water Board (CGWB) has prepared a map showing groundwater availability, which is attached as Fig. 2.2 .

Total Availability

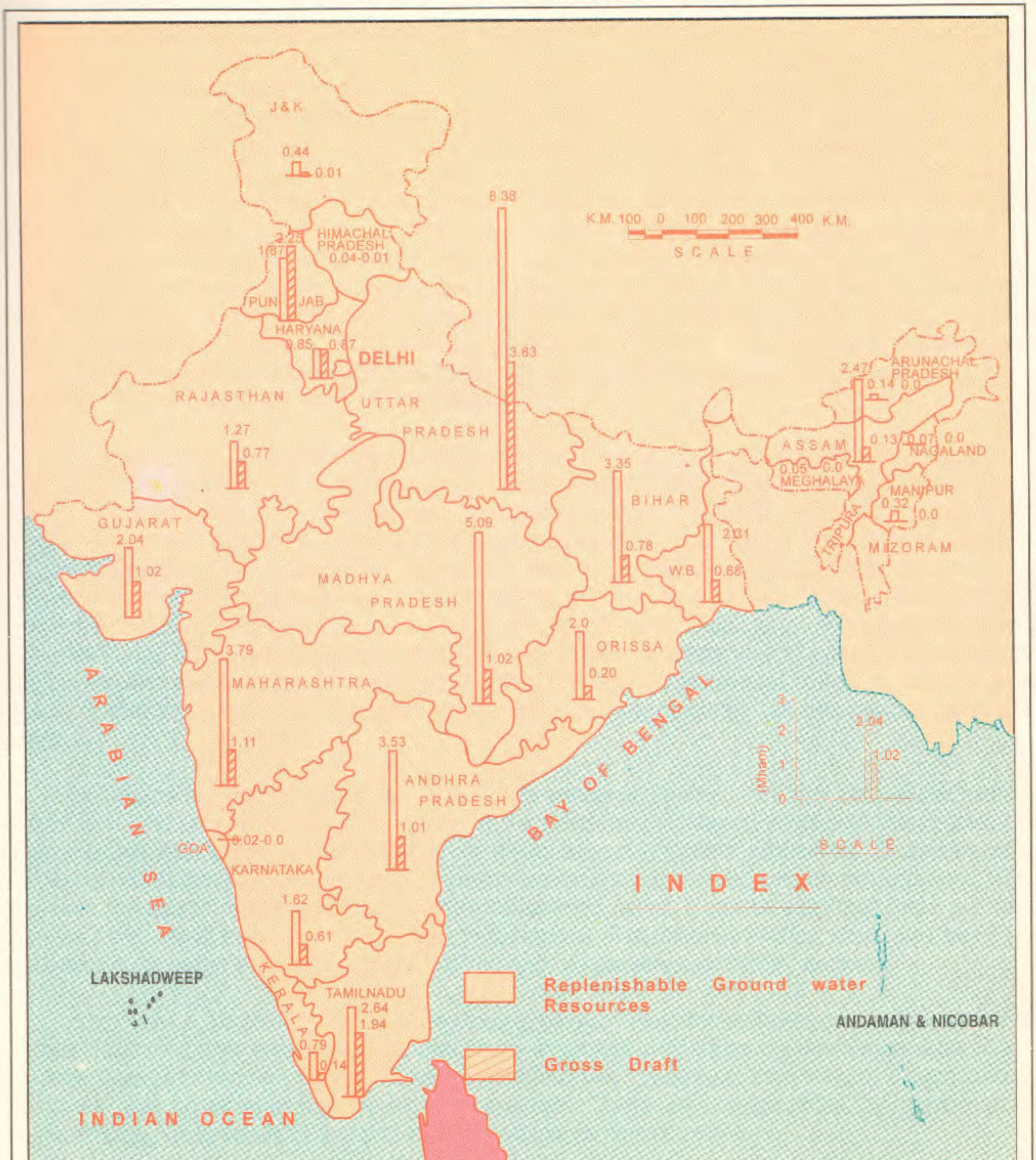
It has been estimated by this Commission that as against a total annual availability of 1,953 km^3 (inclusive of 432 km^3 of groundwater), approximately 690 km^3 of surface water and 396 km^3 from groundwater resources, making a total of 1,086 km^3 , can be put to use. So far, a quantum of about 600 Km^3 only out of this available water, has been put to use. However, pollution problems have been growing, posing a serious threat to availability for use. Municipal sewage (often untreated), urban and rural wastes, industrial effluents, chemical fertilizers and pesticides, have all contributed to the pollution of both surface water and groundwater. At the same time, the demand for water will grow with population growth and the processes of economic development. It has been estimated (as we shall see later in this report) that the available supplies on certain premises will be matched if not exceeded by demand by the year 2050. Water-stress conditions will be experienced in many parts of the country unless remedial measures are taken in time.

2.4 Issues and Concerns

As we try to foresee and plan for the future, it is clear that we need to grapple with several critical issues which are likely to shape our future. Finite availability of water in the face of increasing demand will prompt us to explore all possibilities of bridging the gap between the potential availability and the actual supply. We also realize that even in the optimistic scenario, the task of balancing the availability and the requirement of water will raise major issues of equity and efficiency. Distribution of the available supply between different regions of the country and within the regions between rural and urban areas, or between different sections of population raises questions of prioritisation among various uses as much as the access to water, in quantitative and qualitative terms, at different locations and for different groups of people.

Similarly, we will have to grapple with the issues of efficiency to minimise losses and obtain better results. These issues, in turn, hinge on the strength and flexibility of our legal and institutional mechanisms. They will be profoundly influenced by the economic and technological choices that we make. Above all, these issues would be confronted more satisfactorily to the extent that we are able to evolve a national consensus on the role of different levels of government, institution of civil society and the market. In the subsequent chapters, we shall be discussing in greater detail the emerging issues in the water sector in the coming decades. In this section, we briefly point to the critical areas for integrated development of water resources and present an overview of the subsequent, more detailed, discussion.

FIG 2.2 : REPLENISHABLE GROUND WATER RESOURCES AND GROSS DRAFT FROM GROUND WATER



SOURCE : CENTRAL GROUND WATER BOARD

Water resources are developed for meeting the basic needs like drinking, food production, energy, clothing fibres, besides requirements for navigation, flood control etc. At the time of start of the planning era, the country's food production was at a low level of about 50 million tonnes, requiring massive import of food grains to meet the needs of even a population of only 350 millions. Most of the rural population and large segments of urban population depended on dug wells or river flows for drinking water needs. Many cities were dependent on reservoirs and barrages, even then for their organised water supply and sewarage schemes. There was little hydropower generation then. Drought and floods were taking heavy toll of life and property, besides disrupting the economy frequently. The River Valley Development plans started in a big way since then. The population multiplied alongwith urbanisation and industrialisation. The drinking and public health water needs for these societies grew exponentially. The reservoirs were increasingly built to serve more than one beneficial need. The concept of multipurpose river valley development was adopted. Attainment of self sufficiency in food to have independence of thought and action became the cornerstone of India's water policy. India today has the largest irrigated area in the world. At the end of the present century, the water resources development along-with green revolution, has enabled the country to produce over 200 million tonnes for a nearly tripled population of nearly 1,000 millions and provided food security. In the designing and building of large projects (including big dams, long and intricate tunnel systems, underground power stations, pumped storage facilities, barrages and weirs, vast canal networks, and so on) under complex and difficult conditions, Indian engineering capabilities are second to none. The country's capabilities for the manufacture of much of the equipment needed for the projects (construction and earth-moving equipment, generators, turbines etc.) are also impressive. And yet there are some shortcomings.

An important one is that the preoccupation in the past has been mostly with irrigation. The move away from this orientation towards a larger perspective of `water-resource planning' is a relatively recent development, and has been only partly achieved. There is now a growing recognition that the planning of individual projects must be a part of, and must derive from, a larger plan for a suitable hydrological unit (a basin or sub-basin); that such planning should marry land and water management; that it should be integrated and holistic; that it should be fully `participatory' and should involve the people at every stage; and that it should be inter-disciplinary. However, this has not happened to any significant extent and there is much to be desired by way of people's involvement in the planning and implementation processes. As for environmental/ecological concerns, there is general agreement that they should be `internalized' *ab initio* in project planning, but this has not become fully operative.

Displacement and rehabilitation, again, are areas of concern. In the past these were not handled well. There is increasing appreciation of the need for enlightened policies in this regard, but in actual practice the proper implementation of these policies presents difficulties. Displacement and rehabilitation problems are at the heart of the controversies surrounding certain projects, and without going into the merits of the arguments relating to specific cases, it can be said that there are serious problems here. It is to be hoped that the draft National Rehabilitation Policy which has been under consideration for some time will soon be finalized and will provide satisfactory answers.

Even from a conventional, techno-economic point of view, there have been serious deficiencies in project planning and execution. The processes of project preparation, examination, appraisal and clearance leave much to be desired in terms of rigour and timeliness. Financing and monitoring are inadequate and post-completion evaluations are few. These are compounded by narrow political considerations, not to speak of the problems of collusion and corruption.

In implementation, projects are subject to what are referred to as `time and cost over-runs', i.e. unconscionable delays and enormous increases in project costs. There is the serious problem of spreading available resources thinly and ,therefore, of `spill-over' of projects over several Plan periods. Pious exhortations in Plan after Plan against the thin spreading of resources on too many new starts have largely been ignored because of the pressure for more and more irrigation. Indeed the problems of adequate financial resources, their optimal application and those of financial and project discipline have become almost intractable.

When projects are completed, it is often found that the benefits fall short of the original expectations. Actual cropping patterns are not in consonance with what the project planners envisaged; as a result, the area brought under irrigation is less than what was planned. There has also been problem of a lag in the utilization of the potential created. The response to that problem, namely the Command Area Development Programme, has not worked in the way it was supposed to and has had only a limited success. Further, while on the one hand, a certain irrigation potential is created by a project; on the other, the very practice of irrigated agriculture for some years leads under certain conditions (inadequate drainage, injudicious irrigation) to a loss of valuable agricultural land through the emergence of water-logging conditions and salinization as has happened in some commands.

Irrigation projects, in general, have become poor revenue-earners (in fact in financial terms, they are loss-makers) because of low water rates and still lower collections. The recommendations of various commissions and committees for a revision of water rates on certain principles have largely remained unimplemented due to lack of political support. With a few notable exceptions, the State Governments show little inclination to raise water rates. This aggravates the problem of inadequacy of resources. Lack of funds, combined with the preference in our system for the construction of new projects over the maintenance of existing ones, results in grossly inadequate allocation for the latter. Systems built at great cost are allowed to fall into a dilapidated state. Together with the unresponsive methods of governmental functioning, this renders the system inefficient and unreliable as a provider of water, which in turn makes the user reluctant to accept any increases in water rates, thus setting in motion a vicious circle.

Over the decades the state's capacity for maintaining and operating large irrigation systems and providing a satisfactory service to the farmers has come under severe strain. A further complication is the role that politics plays in water allocation and the power and influence that some rich farmers come to acquire over the operation of the system. All this, and the activities of many NGOs as also a growing feeling that the role of the state should be reduced and the area of management by the people enlarged, have led to a movement for a transfer of the responsibility for the management of irrigation systems at a certain level to Water Users' Associations (WUA). This has come to be known as Participatory Irrigation Management (PIM) or Irrigation Management Transfer (IMT). The movement is in the early stages in our country, but it is bound to make significant headway in the near future.

If we leave the area of large projects and look at minor irrigation and still smaller local water management systems, we come across two sets of problems. The first is a cluster of issues relating to groundwater exploitation. There are areas where canal irrigation in places well endowed with groundwater has led to a rise in the water table and the emergence of waterlogging and salinity problems. There are other areas where groundwater is being mined, i.e. extracted at a rate exceeding that of re-charge, leading to the gradual depletion of the aquifer, and in coastal areas to the incursion of salinity from the sea. Further, only the relatively rich can afford power-operated tubewells and borewells, and their operation could have an adverse impact on others in the neighbourhood who are dependent on the same aquifer. Unfortunately, state-regulation of groundwater extraction is not easy, partly because of political reasons and partly because the laws seem to vest ownership rights in groundwater in the owner of the land above it. A related question is the emergence of water markets, their potential for meeting the water needs of poor farmers who cannot afford to invest in tubewells, and their equal potential for promoting inequitable and exploitative relationships and an unsustainable use of the aquifer. A new development is the establishment of the Central Ground Water Authority under the provisions of the Environment Protection Act and the vesting of that Authority with regulatory powers, having regard to certain directions of the Supreme Court. The Authority has a challenging task and we have to see how it evolves and what kind of regulation is resorted to.

The second cluster of issues relates to traditional community-managed systems of water management (for instance, the tank systems in different parts of the country, the phad system of Maharashtra and the stepwells of Rajasthan). For a number of reasons the physical structures have fallen into disuse and disrepair, and the old traditions and habits of community-management have been almost lost. In recent years, however, there has been a growing body of opinion in favour of restoring and rehabilitating the old systems and reviving the tradition of community management. There is also a movement towards local water-harvesting and watershed development initiatives in various States.

Some hold the view that the answer to the future water needs of a growing population lies in the replicaton of such efforts in thousands of locations across the length and breadth of the country, and that there is no need for large dams or long-distance water transfers with all their adverse impacts, environmental, ecological, social and human. There are others who feel that small scale storages also have their problems like limitations of terrain, reliability and possible health hazards. They argue that given the magnitudes of population projections and future water needs, large `water-development' projects and long distance water-transfers are very necessary; that their impacts and consequences can be fully foreseen and taken into account in the evaluation leading to the investment decision, and appropriate counter-measures provided; and that local water-harvesting and watershed development programmes in rain-fed areas are supplements to such large-scale supply-side projects. A controversy has been raging for quite some time regarding the desirability of large dam projects, and there has been a polarization of attitudes. This is unfortunate. Be that as it may, there can be no disagreement about the desirability of a national movement for water-harvesting and watershed development as an important component of water-resource planning.

Turning now to questions of equity, we are faced with a whole range of issues. First, in the context of large projects there is the question of the inequitable incidence of costs and benefits; one set of people ,that is, those in the submergence area (quite often poor people belonging to tribal communities or weaker sections of society), bear the social costs of the project (displacement, loss of livelihood, etc.), and another set of people, those in the command area, enjoy the benefits. Efforts to give the former a share in those benefits and to regard them as `partners in development' have been inadequate. Secondly, communities living upstream and around reservoir areas also have water and energy needs and are entitled to expect the authorities operating the reservoir and power-station to meet them; but this is not readily recognized.

There are questions of equity amongst the users of reservoir waters between head-reach and tail-end farms, between rich and poor farmers and so on. As waters begin to rise in the reservoir, and canal-systems for taking them to the tail-end are not yet ready, the head-reach farmers have plenty of water available and tend to plant water-intensive crops. This establishes a pattern of water-use that cannot easily be changed at a later stage. Further, with the increasing affluence of the large farmers, their money-power begins to transform itself into political power. Another question is that of equity as between those who are served by the canals from a dam and those who are dependent upon river flow downstream of the dam. In relation to groundwater, we have already referred to the equity issues that arise.

Among the most important issues that need consideration in relation to water-resource planning is that concerning the role of women. The role that women (including even the girl-child) actually play in fetching water, often from distant sources, and managing water in the household, is well-known. Giving them a voice in water-resource planning, consulting them in the formulation of schemes or projects, `empowering' them in the newer institutional arrangements that are coming into being (such as WUAs), and so on, are among the matters that demand attention.

Other matters calling for urgent attention include the sharp deterioration of water-quality (in rivers, surface water-bodies, underground aquifers, and in public water supply systems), the hazards that this poses to the health of the nation, and the ineffectiveness of the law and institutions that are meant to be safeguards against these possibilities; and the shocking waste of water in all uses - agricultural, industrial, municipal, domestic - and the total absence of an awareness of the scarcity of this precious resource. In general, in our anxiety for development, we seem to have been more concerned with what is known as `water-resource development' than with water management. A shift of focus towards water management has been urged and merits serious consideration. The protection of the water-sources (mountains, streams, forests, wetlands, underground aquifers) is another important concern.

Floods give rise to some difficult issues: is flood control feasible? Should we learn to live with floods? Have embankments been good or bad? Why are people in some areas questioning the utility of embankments? What are the measures needed for ensuring that the damage caused by floods is minimized? Is flood-plain zoning feasible?

Contrariwise, how are the needs of the water-short areas of the country to be met? To what extent can this be done through local water-harvesting and watershed development approaches? Should water be transferred to such places from long distances? What local drought-proofing measures can be taken? What types of economic activity and what kinds of water-use should be encouraged in arid or drought-prone areas?

Even now, despite decades of planning and the institution of `Missions', there are large numbers of what are known as `no source' villages, i.e. villages without a source of safe drinking water within a reasonable distance. How is this unacceptable situation to be remedied within a short period of time? The National Water Policy assigns the highest priority to drinking water, but what does this mean in practical terms? What steps does this entail?

That brings us to the subject of water law. Access to water as a basic human (and animal) right needs to be ensured. The water rights of aquatic life and of the natural environment, and indeed of the river itself, need to be protected. There is a legal asymmetry between flowing water (in respect of which only use-rights are recognised and not ownership rights) and groundwater (where, as already mentioned, rights seem to go with land-ownership). Reforms such as PIM, a `participatory' approach to planning, empowering the Panchayats and Nagarpalikas and the community in general, empowering women, and so on, are movements that are gathering strength, but each of them may need some kind of legal backing and mechanisms. Again, the promotion of an awareness of scarcity and the enforcement of water-conservation and economy in water-use may need legal instruments.

Conflicts arise at every level - between different uses of water, between different users, between different areas (inter-group, inter-village, inter-district, inter-State, inter-country). A framework of principles of water-sharing (including the provision of a legal basis for sharing of water between surplus and deficit areas) may be necessary. Answers have to be found to the difficulties that the existing conflict-resolution machinery has run into especially in the case of inter-state disputes, which have become increasingly difficult to resolve. Desirable objectives such as planning for a hydrological unit as a whole (a basin or a sub-basin) may also require the provision of an appropriate legal basis. Having regard to all this, a comprehensive set of inter-related water laws together constituting a National Water Code may need to be worked out. In that context, the question of the adequacy and appropriateness of the existing Constitutional provisions relating to water, and the changes, if any, that are needed, will have to be considered.

Many of the changes that we have referred to in response to issues and concerns will call for a close inter-action between the government and the people. Government functionaries have to learn to work constructively with the people and with the voluntary agencies engaged in social mobilization. They generally find this difficult to do. The general tendency to classify most information as 'secret' makes it very difficult to realize the objectives of participation, empowerment and conflict-resolution. The obsession with secrecy hampers even much-needed research and analytical work, and indeed the functioning of government departments themselves. No proper planning is possible under these circumstances. Major attitudinal and organisational changes would be necessary to deal adequately with all these issues.

2.5 National Water Policy

A National Commission on water resources planning has to perform its task with reference to a certain policy framework. The basic reference document in this regard is the National Water Policy (NWP) approved and adopted by the National Water Resources Council (NWRC) in September 1987 (Annexure- 2.1). We are aware that the NWP is currently under review and that a set of amendments has been proposed by the National Water Board (NWB) for consideration by the NWRC at its next meeting. We have also had the opportunity of seeing the proposed changes and additions. We do not consider it appropriate to comment in detail on a draft submitted by the NWB to the NWRC. Instead, we propose to consider briefly what the NWP 1987 was trying to do, what its limitations were, what new concerns and issues need to be taken into account at this stage and what kind of NWP would emerge if the exercise were being undertaken for the first time today.

Having regard to the importance of water, the federal structure of the country, and the nature of the allocation of responsibilities in respect of water in the Constitution, the need for a national consensus on a policy framework is clear. It was an awareness of this that led to the formulation of the NWP 1987. The aim was to get all the States to subscribe in broad terms to a minimal set of propositions of a general nature, which could then form an agreed basis for more detailed policy-making and action plans. National consensus of a kind was indeed achieved, and the NWP was adopted in 1987. That was doubtless an important milestone, but the achievement should not be exaggerated. First, there were certain compromises. The statement that water was a national resource is qualified by the expression "subject to the needs of the States". Similarly, the document envisages planning for a hydrological unit such as a basin or sub-basin, but refrains from mentioning River Basin Authorities or Commissions, doubtless because of apprehensions on the part of the States that their own powers would be eroded. A reference to the optimal use of available water resources (paragraph 3.3) stands qualified by the words "having regard to subsisting agreements or awards of tribunals". These qualifications and compromises are not matters for regret, as they served the important purpose of facilitating a broad national consensus, but perhaps the time has come for us to see if we cannot proceed a little beyond the 1987 consensus. Secondly, certain aspects or areas are not covered in the NWP, doubtless because they were matters on which it would have been extremely difficult to reach a consensus. Thirdly, more than a decade after the adoption of the NWP, the operationalization of the policy has not made much headway; it still remains largely a set of general propositions. Fourthly, some of the current concerns and issues were still of fairly recent origin when the document was being formulated and have been much more sharply articulated since then. They, therefore, do not find a place in the policy.

It is clear that if the NWP were being drafted today, it would need to show a much greater awareness of the present climate of opinion in regard to many matters such as environmental and ecological issues, 'sustainable development', questions of displacement of people and their resettlement and rehabilitation, the impact of developmental activities on disadvantaged sections of the society and on tribal communities, the need to remove women's disabilities and 'empower' them, and so on. The increasing acceptance of ideas such as a 'participatory' approach to project planning, the involvement of 'stakeholders', the need for public hearings, the transfer of the management of irrigation systems at a certain level to farmers' associations, and so on, would need to be recognized. The growing awareness of the importance of local water-harvesting and watershed development activities, the imperative of social mobilization in this context, the 'success stories' and other experience in this regard and the need for a replication of these into a national movement, would need to be reflected. The rediscovery of value in traditional systems of water harvesting and management and the movement for restoring the role of the community in the management of common resources would need to be taken note of. The prognosis that the world as a whole is moving towards a situation of water scarcity and that the stress is likely to be very severe in certain regions, and the appropriate responses to the projected crises, will have to be central to the new policy. The recognition of access to water as a basic human right, and a profound concern for equity and social justice, will have to be reflected in the policy.

It would also be necessary to go into some other issues left out of the existing NWP. The issue of the legal / constitutional framework, skirted at the time of the formulation of the National Water Policy, will have to be looked at afresh. A new dimension has been added to this by the advent of Panchayats as one more tier in the federal structure, as also by the movement, not yet very strong, for 'empowering the people'. Moreover, considering the fact that in recent years, the process of adjudication of inter-state river water disputes has run into serious difficulties, it may be useful to set forth the changes needed in the adjudication system. Lastly, some of our important river systems are trans-boundary systems and involve negotiations with neighbouring countries (Nepal, Bangladesh); the new policy may have to take note of this dimension.

We do not propose to offer detailed suggestions for changes in the existing NWP or attempt a draft of a new policy document. We have only tried to visualize the kinds of issues and concerns that such an exercise would need to take into account. However, almost all these matters will inevitably come up for consideration in the various chapters of this report.

Two concluding observations may be made. The first is that the concerns and considerations outlined above seem to call for a fresh exercise of drafting a policy document rather than going in for amendments and additions. The second is that the policy document will need to be accompanied by a detailed blueprint for converting its generalities into operational plans; without such a blueprint, the whole exercise of redrafting the NWP may not achieve its purpose.

CHAPTER - 3

WATER AVAILABILITY AND REQUIREMENTS

I. Water Availability

Proper assessment of the availability of water from surface and sub-surface sources is crucial for its proper planning, development and efficient management. Precipitation, in the form of rain and snowfall, is a crucial component of the hydrological cycle which makes fresh water available on a renewable basis. The geographical area of the country is 329 million hactares (Mha). The mean annual rainfall, taking the country as a whole, is 1,170 mm. This gives an annual precipitation of about 4,000 km^3. A significant part of this precipitation returns back to the atmosphere as evaporation. A large part of the remaining precipitation seeps into the ground and the balance flows through streams and rivers and collects in water bodies adding to the surface flow. A part of the water which seeps into the ground remains as soil moisture in the upper layers and the rest adds to the ground water resource. Subsequently, a major part of the water from surface flows, soil moisture and ground water sources, when put to various uses, returns to the atmosphere through evapo-transpiration and evaporation. Part of the water from surface flows may enter ground water and add to ground water resource and part of the ground water again returns to streams and rivers. Thus the surface and the ground water sources are inter-linked and are continuously inter-active. It is, therefore, extremely difficult, if not impossible, to quantify them separately over a period of time in given locations.

However, for the purposes of accounting for water resources by basins or regions, a simplified approach is necessary according to which we can make separate assessment of surface and ground water resources.

3.1 River Basins

River basin is the basic hydrologic unit for planning and development of water resources. It is, therefore, useful and convenient to make the assessment of water resources basin wise. A system of rivers normally flowing into a common terminus constitute a single drainage basin as per the definition given in the Convention on the Non-navigational Uses of International Water Courses adopted by the United Nations.

Based on the physiography, the river systems of India can be classified into four groups, viz. (i) Himalayan rivers, (ii) Deccan rivers, (iii) Coastal rivers, and (iv) Rivers of the inland drainage basin. The main Himalayan River Systems are those of Indus and Ganga-Brahmaputra-Meghna systems. The Himalayan rivers receive very heavy rainfall in monsoon months and the rivers swell, causing frequent floods. The flows in the summer months are due to melting of snow and glaciers and, therefore, these rivers have continuous flow throughout the year. The important river systems in the Deccan are the west flowing rivers of Narmada and Tapi and the east flowing rivers of Brahmani, Baitarni, Mahanadi, Godavari, Krishna, Pennar and Cauvery. The Deccan rivers are rainfed and some of them are non-perennial. There are numerous coastal rivers which are comparatively small. Most of them are non-perennial. While only a handful of such rivers drain into the sea near the deltas of east coast, there are as many as 600 such rivers on the west coast. The west coast rivers are short in length and have limited catchment areas. A few rivers in Rajasthan do not drain into the sea. They drain into salt lakes or get lost in sands with no outlet to sea.

Earlier, the entire country was suitably divided into 20 river basins by the Central Water Commission. These comprised 12 major basins (having a drainage area exceeding 20,000 sq.km.) and eight other river basins each combining a number of medium and minor rivers. However, it was seen that some areas such as the area north of Ladakh not draining into Indus and areas of Andaman, Nicobar and Lakshadweep islands are not covered in the 20 river basins. In consultation with the Central Water Commission, we reviewed the grouping of the river basins. Based on this review, the drainage area of the country has now been divided into 24 basins, which includes two basins, namely areas of North Ladakh not draining into Indus and Drainage area of Andaman, Nicobar and Lakshadweep Islands. The group of minor rivers of East Coast, South of Mahanadi have been divided into five basins in place of the earlier two basins and the rivers draining into Myanmar and Bangladesh have been grouped under two separate basins, in place of the earlier one basin. The rivers of West Coast South of Tapi are grouped into one basin in place of the earlier two basins. Area of inland drainage of Rajasthan which was one of the twenty basins is deleted. The list of basins so proposed alongwith their catchment areas is given in Table 3.1. The Statewise basin wise areas are shown in Annexure – 3.1.

During the review, it was noticed that there were some discrepancies in the reported drainage area of the Indus basin. Both the reports of the Second Irrigation Commission (1972) and the Ravi Beas Waters Tribunal (1987) had adopted the area of Indus Basin as 3,21,289 km^2 on a watershed basis. However, as per the delineation of the basin boundary shown in the map in the Central Water Commission Publication (1989) "Major River Basins of India - An Overview", the area of the basin appears to be more than 3,21,289 km^2. We recommend that this may be looked into. For our purposes, we are using the area of 3,21,289 km^2 for the basin, since the same has been used by the earlier reports.

Ganga, Brahmaputra and Meghna rivers flow into a common terminus before joining the Bay of Bengal; hence, Ganga- Brahmaputra- Meghna is considered as a basin, and Ganga, Brahmaputra and Meghna rivers are considered as sub-basins of Ganga- Brahmaputra -Meghna basin. Brahmani and Baitarani river systems outfall into Bay of Bengal forming a common delta; hence, Brahmani-Baitarani constitute a single basin.

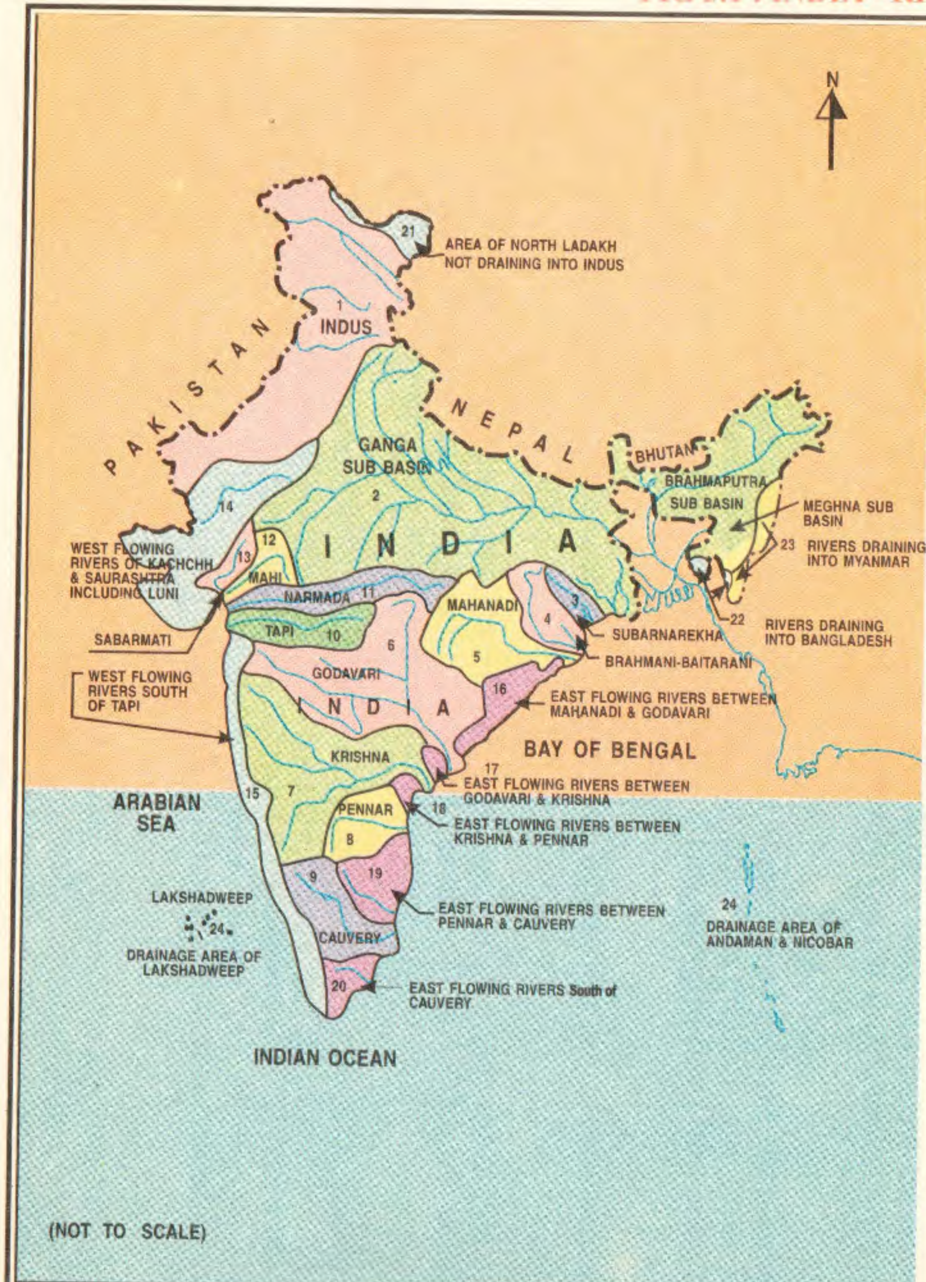
The catchment areas and location of the basins are shown in Fig. 3.1

Table - 3.1
Catchment Area of Basins

S.No.	River Basin	Catchment Area, km^2	States Covered in the Basin
1	2	3	4
1	Indus	321289	J&K, Punjab, Himachal Pradesh, Rajasthan and Chandigarh.
2	Ganga-Brahmaputra-Meghna Basin :		
2a	Ganga Sub-basin	862769	Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh, Bihar, West Bengal and Delhi UT.
2b	Brahmaputra sub-basin	197316	Arunachal, Assam, Meghalaya, Nagaland, Sikkim and West Bengal.
2c	Meghna (Barak) sub-basin	41157	Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura.
3	Subernarekha	29196	Bihar, West Bengal and Orissa.
4	Brahmani-Baitarani	51822	M.P., Bihar and Orissa.
5	Mahanadi	141589	M.P., Maharashtra, Bihar and Orissa.
6	Godavari	312812	Maharashtra, A.P., M.P., Orissa and Pondicherry.
7	Krishna	258948	Maharashtra, A.P. and Karnataka.
8	Pennar	55213	A.P. and Karnataka.
9	Cauvery	87900	Tamilnadu, Karnataka, Kerala and Pondicherry.
10	Tapi	65145	M.P., Maharashtra and Gujarat.
11	Narmada	98796	M.P., Maharashtra ad Gujarat.
12	Mahi	34842	Rajasthan, Gujarat and M.P.
13	Sabarmati	21674	Rajasthan and Gujarat.
14	West Flowing Rivers of Kachchh, Saurashtra and Luni.	334390	Rajasthan, Gujarat and Daman and Diu.
15	West Flowing Rivers south of Tapi	113057	Karnataka, Kerala, Goa, Tamil Nadu Maharashtra, Gujarat, Daman and Diu and Nagar Haveli.
16	East Flowing Rivers Between Mahanadi and Godavari.	49570	A.P. and Orissa.
17	East Flowing Rivers Between Godavari and Krishna.	12289	Andhra Pradesh.
18	East Flowing Rivers Between Krishna and Pennar.	24649	Andhra Pradesh.
19	East Flowing Rivers Between Pennar and Cauvery.	64751	A.P., Karnataka and Tamilnadu.
20	East Flowing Rivers south of Cauvery	35026	Tamilnadu and Pondicherry UT.
21	Area of North Ladakh not draining into Indus	28478	Jammu and Kashmir.
22	Rivers draining into Bangladesh	10031	Mizoram and Tripura.
23	Rivers draining into Myanmar.	26271	Manipur, Mizoram and Nagaland.
24	Drainage areas of Andaman, Nicobar and Lakshadweep Islands.	8280	Andaman, Nicobar and Lakshadweep.
	Total	**3287260**	

Source: See text

FIG 3.1 : INDIA - RIVER BASINS



S.No.	Name of Basin
1.	Indus
2.	Ganga-Brahmaputra-Meghna Basin
3.	Subarnarekha
4.	Brahmani-Baitarani
5.	Mahanadi
6.	Godavari
7.	Krishna
8.	Pennar
9.	Cauvery
10.	Tapi
11.	Narmada
12.	Mahi
13.	Sabarmati
14.	West Flowing Rivers of Kachchh and Saurashtra Including Luni.
15.	West Flowing Rivers South of Tapi.
16.	East Flowing Rivers between Mahanadi and Godavari
17.	East Flowing Rivers between Godavari and Krishna
18.	East Flowing Rivers between Krishna and Pennar
19.	East Flowing Rivers between Pennar and Cauvery
20.	East Flowing Rivers South of Cauvery
21	Area of North Ladakh Not draining into Indus
22	Rivers draining into Bangladesh
23	Rivers draining into Myanmar
24	Drainage Area of Andaman and Nicobar and Lakshadweep

3.2 Water Resource

Natural (virgin) flow in the river basin is reckoned as water resource of a basin. The mean flow of a basin is normally obtained on pro-rata basis from the average annual flow at the terminal site.

Water resources have already been developed and utilised to a considerable extent in various river basins through construction of major or medium storage dams and development of hydro power, irrigation and other water supply systems. A large number of diversion schemes and pumped storage schemes have also been in operation. Assessment of natural flow has become complex in view of the upstream utilisation, reservoir storages, re-generated flows and return flows . The natural flow at the location of any site is obtained by summing up the observed flow, upstream utilisation for irrigation, domestic and industrial uses both from surface and ground water sources, increase in storage of reservoirs (surface and subsurface) and evaporation losses in reservoirs, and deducting return flows from different uses from surface and ground water sources.

The data on utilisation for irrigation purpose are generally obtained from the records maintained by irrigation project authorities. Where such records are not available, the abstractions for irrigation are estimated from information on area irrigated and the delta. Data on withdrawals for domestic and industrial uses are not readily available. Hence, only rough estimates are made on the basis of population and available information on per capita domestic and industrial uses. For some of the existing reservoirs, records of evaporation losses are maintained by the project authorities. In case of projects where such data are not available, generally 20 percent of annual utilisation is taken as evaporation loss.

The total ground water draft for the country as a whole is estimated by the Central Ground Water Board periodically. Ground water utilisation for different years is estimated based on ground water draft.

Return flows from irrigation use are assumed as 10 to 20 percent of the water diverted from the reservoir for irrigation. In case of localised use of ground water for irrigation, the return flow is assumed to be negligible. The return flows from domestic and industrial uses either from ground water or surface water source are assumed to be 70 to 80 percent.

Estimates of surface water resources of the country attempted from time to time are discussed below :

- The Irrigation Commission (1901-03) estimated the average annual flow of all river systems of undivided India (excluding Assam, Burma and East Bengal) as 1,443.2 km^3 by adopting coefficients of runoff in the absence of data on river flows.

- The estimate of surface water resources was revised in 1949 by Dr. A. N. Khosla, using more refined empirical relationships. He divided the country into six regions. viz. (i) Rivers falling into Arabian Sea excluding Indus, (ii) Indus Basin within India, (iii) Rivers falling into Bay of Bengal other than the Ganga-Brahmaputra system, (iv) the Ganga, (v) the Brahmaputra and (vi) Rajputana. According to Dr. Khosla, total annual flow of all the river systems was 1,673 km^3.

- The Central Water and Power Commission during 1954-66 estimated the surface water resources of different basins in the context of irrigation potential studies undertaken by them. This study was mostly based on statistical analysis of the flow data wherever such data were available, and on rainfall-runoff relationships where flow data were meagre or not available. The country was divided into five zones namely, West flowing rivers, East flowing rivers, Indus basin, Ganga basin and Brahmaputra and Barak basin. The water resource of all the basins taken together was estimated as 1,881 km^3 .

- The National Commission on Agriculture (1976) estimated total annual water resource of the country as 1,850 km^3 (1,800 km^3 available in an average year) based on water balance approach taking into account rainfall, percolation of water in soils, evaporation and evapo-transpiration .

- Some studies were also done by different bodies from time to time in respect of a few individual basins for specific purposes. These estimates were based on observed flow data at terminal site and observed flows were corrected for upstream utilisation of surface water resource. However, the correction for additional evapo-transpiration due to ground water use was not done. The sources of the study, respective basins and the estimates are given in Table 3.2.

Table-3.2
Average Annual Run-off Estimated by Different Agencies

S.No.	Source of the Study	Basin	Water Resource, km^3 per year
1.	Indus Commission (1960)	Indus	73.305*
2.	Krishna Godavari Commission (1962)	Godavari	118.982
3.	Cauvery Fact Finding Committee (1972)	Cauvery	20.957
4.	Krishna Water Disputes Tribunal (1973) **	Krishna	67.790
5.	Narmada Water Diputes Tribunal (1979) **	Narmada	40.950
6.	Committee for Assessment of Water Resources of Rivers Falling into Arabian Sea (1982)	West Flowing Rivers from Tapi to Tadri Rivers South of Tadri	108.618 89.250
7.	Ganga Brahmaputra Water Studies (GBWS) (1982)	Ganga	501.643
8.	Brahmaputra Board (1987)	Brahmaputra	537.067
9.	Central Water Commission (1987) Do Do Do	Mahanadi Subernarekha Sabarmati Tapi	66.879 10.756 3.812 18.000

* *This figure was included in the earlier estimate of 1960.*
** *The Tribunals have given awards based on 75 percent dependability, whereas the assessment by the National Commission is based on average flow.*

- Central Water Commission revised the estimate of average annual water resources potential of the country in 1988. The average annual flows of the Indus, Ganga, Brahmaputra, Godavari, Krishna, Cauvery, Mahanadi, Subernarekha, Sabarmati, Narmada, Tapi, West flowing rivers were corrected for utilisation of ground water draft. The assessment of water resource of other basins was based on Dr. Khosla's formula and runoff was not estimated on the observed river flows and hence, no corrections were made. The total water resource of 20 basins was estimated as 1,879.45 km^3 (say, 1,880 km^3).

- National Water Development Agency (NWDA) estimated surface water resources of sub-basins in Godavari, Krishna, Cauvery, Pennar, Brahmani-Baitarni, Mahanadi, two basins of East flowing rivers, West flowing rivers from Tadri to Kanyakumari and West flowing rivers from Tapi to Tadri (except rivers of Konkan region of Maharashtra). The mean flows of these basins were obtained from the mean flows of their sub-basins worked out from the yield series developed for sub-basins. These are given in Table 3.3.

Table-3.3
Annual Mean Flow as estimated by NWDA

S.No.	River Basin	Mean Flow, km^3 per year
1.	Godavari*	119.84
2.	Krishna	68.57
3.	Cauvery	20.51
4.	Brahmani- Baitarani	29.50
5.	Mahanadi	73.30
6.	Pennar	4.16
7.	West Flowing Rivers south of Tadri **	120.17
8.	East Flowing Rivers between Mahanadi to Pennar	20.95
9.	East Flowing Rivers between Pennar and Cauvery and south of Cauvery.	15.26

* *Basin in the reach from Sriramsagar Project and Polavaram*
** *Covers rivers of Karnataka, Kerala and Tamil Nadu.*

- A Committee headed by Member (WP), Central Water Commission was constituted by the Ministry of Water Resources in January, 1989 to re-assess the surface water resources in the country. The results of the studies carried out by the Committee were published by CWC. The findings of the Committee were as follows :

  (a.) A reassessment study was carried out in respect of 12 river basins namely, Godavari, Krishna, Pennar, Subernarekha, Brahmani-Baitarni, two basins of East flowing rivers, Sabarmati, Mahi, Tapi and two basins of West flowing rivers. The estimate of the total water resource of these 12 basins as re-assessed was 505.454 km^3.

  (b.) The water resource of Barak(Meghna) sub-basin was estimated by the Brahmaputra Board only for the portion of Barak upto border of India with Bangladesh. The water resource of the Barak river estimated by the Brahmaputra Board at Badarpurghat for a catchment area 25,070 sq.km., about 10 km upstream of the border, was 29.06 km^3. Total catchment area of Barak in

India is 41,723 Sq. km. The water resource of the entire sub-basin was estimated to be 48.36 km^3 on the basis of proportion of catchment area.

(c.) The annual flow series at Garudeshwar site, for a basin area of 89,345 sq.km. on Narmada river, were developed for the period 1891-1970, based on the observed flows at this location from 1948 to 1990. The catchment area of Narmada is 98,796 Sq. Km. Water resource for the whole of Narmada basin was estimated as 45.64 km^3 on pro-rata basis.

(d.) No fresh attempt was made for estimating the water availability of Indus, Ganga, Brahmaputra, Mahanadi and Cauvery rivers. The estimates of average annul flows of these basins were made by the agencies indicated in Table 3.2. Subsequently, CWC in their study in 1988 carried out correction in the estimates by taking into account the effect of utilisation of ground water. The same estimates were considered by the CWC in their study in 1993. Total water resources of the above river basins were thus estimated as 1,150.5 km^3.

(e.) The water resource of West Flowing rivers of Kutch and Saurashtra including Luni was estimated as 15.10 km^3, on Dr.Khosla's formula, as the estimate of water resource of this basin could not be reassessed on the basis of the observed run-off data for want of reliable data at any site in the basin.

(f.) The estimate of water resource of 'Rivers Draining into Myanmar and Bangladesh' could not be carried out for want of reliable run-off data, and was roughly assessed by CWC in 1988 as 31 km^3.

Total water resources of the country were estimated by the CWC in 1993 as 1,869.37 km^3 (1,870 km^3). This estimate does not cover the water resource of areas of North Ladakh not draining into Indus and Island of Andaman, Nicobar and Lakshdweep. Basinwise distribution of these water resources is shown in Table 3.4.

We reviewed the estimates of average flows made by CWC and NWDA and by Committees, Commissions and Tribunals. NWDA has estimated mean flows for a few basins only. The mean flows of the basins estimated by NWDA are not based on the observed flows at terminal sites. These were computed from yield series developed for sub-basins, using the rainfall - runoff relationship established at gauging sites in sub-basins. Ground Water utilisation was not considered for estimates of natural flow at gauge and discharge sites. Hence, the mean flows estimated by NWDA were not found adequate by the Commission.

We adopted the estimates of water resources for 18 basins and Ganga and Meghna sub-basins of Ganga- Brahmaputra -Meghna basin as given in the CWC Report of 1993. Some modifications have been made in the case of Brahmaputra sub-basin and Krishna basin.

The Brahmaputra Board in their report of 1987 on "Master Plan of Brahmaputra Basin: Part I - Main Stream" indicated the average annual flow at Jogighopa on Brahmaputra as 537.067 km^3 on the basis of the observed flow in the years 1955-57 and 1971-77. The figure was subsequently corrected to 537.24 km^3 in 1988 after accounting for actual utilisation of ground water draft. Important tributaries like Champamati, Gaurang, Sankosh, Gadadhar, Tipkai, Torsa, Jaldhaka, Teesta (all North Bank tributaries) and Jinjiram, (South Bank tributary) join Brahmaputra downstream of Jogighopa. Average mean flows of these tributaries obtained from observed flows at G&D sites on these rivers were collected from the Brahmaputra Board. Total mean flow of these tributaries are worked out in proportion to the catchment area of each tributary at gauging site and the catchment area of the tributary lying in the country. The total mean flow of these tributaries has been worked out as 91.81 km^3. This additional quantity has been added to the estimated water resources of Brahmaputra sub-basin. Water resources of Brahmaputra sub-basin have, therefore, now been taken as 629.05 km^3 against 537.24 km^3 estimated earlier at the Jogighopa site.

The Krishna Water Disputes Tribunal (KWDT) allotted 58.333 km^3 of water, estimated at Vijayawada site at 75 percent dependability, amongst Maharashtra, Andhra Pradesh and Karnataka. KWDT developed an annual yield series at Vijayawada G&D site for 78 years from 1894-95 to 1971-72. The mean flow at the Vijayawada site, intercepting a catchment area of 2,51,369 km^2, as per the yield series given in the KWDT report, is 67.78 km^3 (2,390 TMC). Average annual flow for the whole basin for catchment area of 2,58,950 km^3 works out to 69.81 km^3 on prorata basis. This potential does not include the actual ground water utilisation. However, CWC in the study of 1988 observed that evapotranspiration attributable to ground water use was negligible. We have adopted the figure of 69.81 as estimate of water resource of the Krishna basin against 78.12 km^3 estimated by CWC in 1993 on the basis of observed flows at Vijayawada for the period 1971-85.

The total water resource of the country as assessed by us thus works out to 1,952.87 km^3 (say 1,953 km^3). Basinwise estimates of water resources by CWC in 1993 and by us are shown in Table 3.4 for comparison.

The water resources of the Ganga-Brahmaputra-Meghna include the waters originating in the neighbouring countries as the assessment is based on the natural flow at the terminal sites in the country.

SKEWED DISTRIBUTION OF WATER RESOURCE IN THE COUNTRY

Basin	Area, Mha	Water Resource, Km^3	Utilisable Surface Water Resource, Km^3
Ganga-Brahmaputra-Meghna	110.13 (33.5 %)	1202 (62 %)	274 (40%)
West Flowing Rivers south of Tapi	11.31 (3.5%)	201 (10%)	36 (5%)
Other Basins	207.29 (63%)	550 (28%)	380 (55%)
Total	**328.73**	**1953**	**690**

Note : Figure in the bracket is percentage of the total under the column.

Table - 3.4

Water Resource - Basin wise

S.No.	River Basin	Water Resource, km³/per year	
		As per CWC 1993	As per NCIWRDP 1999
1	2	3	4
1	Indus	73.31	73.31
2	Ganga-Brahmaputra-Meghna Basin		
2a	Ganga	525.02	525.02
2b	Brahmaputra sub-basin	#537.24	*629.05
2c	Meghna (Barak)sub-basin	48.36	48.36
3	Subarnarekha	12.37	12.37
4	Brahmani-Baitarani	28.48	28.48
5	Mahanadi	66.88	66.88
6	Godavari	110.54	110.54
7	Krishna	##78.12	**69.81
8	Pennar	6.32	6.32
9	Cauvery	21.36	21.36
10	Tapi	14.88	14.88
11	Narmada	45.64	45.64
12	Mahi	11.02	11.02
13	Sabarmati	3.81	3.81
14	West Flowing Rivers of Kachchh and Saurashtra including Luni	15.1	15.1
15	West Flowing Rivers south of Tapi	200.94	200.94
16	East Flowing Rivers Between Mahanadi and Godavari	17.08	17.08
17	East Flowing Rivers Between Godavari and Krishna	1.81	1.81
18	East Flowing Rivers Between Krishna and Pennar	3.63	3.63
19	East Flowing Rivers Between Pennar and Cauvery	9.98	9.98
20	East Flowing Rivers south of Cauvery	6.48	6.48
21	Area of North Ladakh not draining into Indus	0	0
22	Rivers draining into Bangladesh	8.57	8.57
23	Rivers draining into Myanmar	22.43	22.43
24	Drainage areas of Andman, Nicobar and Lakshadweep Islands	0	0
	Total	1869.37	1952.87
	Say	**1870**	**1953**

Source: *Reassessment of Water Resources Potential of India - CWC, Publication 6/93.*

Average flow up to Jogighopa as estimated by Brahmaputra Board.

* *Includes additional contribution of 91.81 km³ being flow of 9 Tributaries joining Brahmaputra downsteam of Joghighopa site.*

Estimate of CWC based on run-off data at Vijaywada site.

** *Based on meam flow of the yield series accepted by KWDT Award.*

While suggesting the figure of 1953 km³ as water resource of the country, we recognise the limitations of these estimates, which in turn are based on the studies cited above. Important limitations are as follows:

- The accuracy of the assessment of water resources of a river basin made on the basis of river flows measured at a terminal site on the river depends on the accuracy of discharge observations, the reliability of the data on the abstractions upstream, the ground water withdrawal, the changes in the storages and evaporation losses of the reservoirs and the return flows / regenerated flow from various uses. All these estimates are not firm. The assessment was based on the discharge observations conducted by CWC; however, the period for which data were collected varied in different basins. There are number of small streams in the West Flowing Rivers and East Flowing Rivers; of those only a small number of rivers are gauged. The assessment of water resources of the ungauged streams is based on the rainfall - runoff relationship. Three basins, namely West Flowing Rivers of Kachchh and Saurashtra, and Rivers draining into Myanmar and rivers draining into Bangladesh cover the catchment area of 3,70,692 km^2 which is 11.3 percent of total geographical area of the country. The total water resources of these basins are assessed as 2.4 percent of the total water resources of the country. In the absence of flow data in these basins, this is only an approximate assessment. The estimates of two basins, namely area of North Ladakh not draining into Indus and drainage areas of Andaman, Nicobar and Lakshdweep islands covering a catchment area of 36,758 km^2 have not been made.

- Major consumption of water in most of the river basins is by irrigation. The State governments do not maintain proper record for other important uses. In many cases the utilisation figures are not available and varying assumptions had to be made to estimate the quantities of utilised water.

- In most of the cases the year-wise withdrawal from ground water was estimated on the assumption of linear variation between the state-wise draft given by the Irrigation Commission (1972) for the year 1967-68 and by the Central Ground Water Board for the year 1983-84, by interpolating for other years.

- The return flow for irrigation from surface water resources was assumed as 10-20 percent of use and the return flow from ground water use was not accounted for. The return flows for domestic and industrial uses were assumed as 80 percent of the use. The irrigation efficiency of surface water was estimated to be in the order of 30-40 percent, and efficiency of ground water use about 70-75 percent. Considering the efficiencies of surface and ground water use in irrigation system, the assumed return flows may be on lower side.

- The evaporation losses were assumed as 20 percent of the annual utilisation wherever the records of evaporation losses were not maintained by project authorities.

We suggest that CWC should take up the work of further refining the assessment of water resources of various basins and collect reliable data pertaining to observed flows, utilisation from surface and ground water resources for irrigation, domestic and industrial uses and evaporation losses. The return flows from irrigation and from other uses for surface as well as ground water resources should be estimated after considering the prevailing irrigation efficiency of the system. More accurate observations on irrigation efficiencies are needed. The State Governments and relevant Central Government agencies responsible for collecting data regarding utilisation, ground water withdrawal, evaporation and storage fluctuation etc. may also be associated with these assessment studies. It is desirable that such reassessment should be carried out periodically.

Some States, such as Bihar, Rajasthan etc., have made basin-wise assessment of water resources; these assessments should also be taken into consideration by the CWC while reassessing water resources. State-wise assessment of surface water resources would also be desirable as the states are primarily responsible for planning and development of water resources.

The average annual virgin flow at the terminal point of a river is generally taken as the water resource of the river basin. But this resource is available with a probability of about 50 percent, whereas irrigation projects are planned for 75 percent dependability, power projects are planned for 90 percent dependability and domestic water supply projects are planned for nearly 100 percent dependability. For the purpose of project planning, higher degree of reliability of water availability is desirable to ensure viability of projects. 75 percent dependability has no operational significance if used for the basin as a whole. It cannot be obtained by a simple aggregation of 75 percent dependable flows of different sub-basins of a basin.

3.3 Utilisable Water Resource

Utilisation of water resource can be taken as the quantum of withdrawable water from its place of natural occurrence such as river or ground water. Alternatively, it can be considered as additional evaporation/evapo-transpiration of water when used for different purposes i.e. domestic, agricultural, industrial etc. The former approach has been used more commonly. This approach is also used in estimating the utilisable flow. Withdrawablity of water largely depends on the existence/possibility of storage and diversion structures and land availability. There are limits to the creation of such structures due to physiographic conditions, environment consideration, extant of technology and problem of resettlement and rehabilitation. Financial viability of the projects for storage and diversion is also a major consideration. Other constraints could be the reliability of flows, say 75 percent dependability.

Conventionally, water resources have been utilised through run-of-the-river schemes and storage reservoirs. The canal system in both these types of schemes is normally built for supply of water by gravity. Sometimes water is directly pumped from the river for use. About 80 percent of the river flows occur in four months of the monsoon. During this period, maximum utilisation of the water can be made from the run-of the-river diversion schemes with small modifications for regulation which require very little storage. About 250 barrages/anicuts have been constructed and 45 barrages/anicuts are under construction. The barrages likely to be constructed in the future have not been identified.

For the use of water during the non-monsoon seasons, there is a need for building up of storage capacities in reservoirs and storage tanks. The total storage built up in the projects completed upto 1995 is about 174 km^3. From projects under construction, another 76 km^3 of storage capacity is likely to be added. Small tanks provide about 3 km^3. This gives a total available storage of 253 km^3. From identified future projects, another 132 km^3 can be added making a total of 385 km^3. Basin wise figures are shown in Table 3.5. It can be shown that this is the bare minimum live storage needed to balance seasonal flows in an average year. Without availability of this much storage, the assumption of 690 km^3 of utilisable surface water(see later) will not be valid. If more storage could be developed, carry over from years of above normal rainfall to dry years would be possible.

STORAGE CAPACITIES IN DIFFERENT STATES

Unit : Km^3

State	Completed	Under Construction	Total
Madhya Pradesh	18.6 (11%)	21.6 (29%)	40.2 (16%)
Maharashtra	22.1 (13%)	12.9 (17%)	35.0 (14%)
Andhra Pradesh	24.8 (14%)	7.1 (9%)	31.9 (13%)
Karnataka	21.6 (12%)	3.0 (4%)	24.6 (10%)
Uttar Pradesh	16.4 (9%)	7.1 (10%)	23.5 (9%)
Gujarat	14.9 (9%)	7.3 (10%)	22.2 (9%)
Orissa	14.3 (8%)	3.3 (4%)	17.6 (7%)
Himachal Pradesh	13.8 (8%)	0.1 (0%)	13.9 (6%)
Other States	27.2 (16%)	13.0 (17%)	40.2 (16%)
Total	**173.7**	**75.4**	**249.1**
Say	**174**	**76**	**250**

Notes : i) Figure in the bracket is rounded off percentage of total under the column
ii) Storages having capacity 10 mcum and above are considered.

Source: Water and Related Statistics, CWC (1998).

Utilisable surface water was estimated in the past by different authorities. The Irrigation Commission (1972) placed the country's utilisable quantities at 666 km^3 from surface water. The National Commission on Agriculture estimated the utilisable quantity as 700 km^3. Dr. K.L. Rao, however, suggested that the utilisable flows should be nearly 50 percent of annual water resources.

Table - 3.5
Storages in India - Basinwise

S.No.	River Basin	Live Storage Capacity, km^3			
		Completed Projects	Projects under Construction	Total	Projects under Consideration
1	2	3	4	5	6
1	Indus	13.83	2.45	16.28	0.27
2	Ganga-Brahmaputra-Meghna Basin				
2a	Ganga sub-basin	36.84	17.12	53.96	29.56
2b,c	Brahmaputra and Meghna sub-basins	1.09	2.40	3.49	63.35
3	Subarnarekha	0.66	1.65	2.31	1.59
4	Brahmani-Baitarani	4.76	0.24	5	8.72
5	Mahanadi	8.49	5.39	13.88	10.96
6	Godavari	19.51	10.65	30.16	8.28
7	Krishna	34.48	7.78	42.26	0.13
8	Pennar	0.38	2.13	2.51	NA
9	Cauvery	7.43	0.39	7.82	0.34
10	Tapi	8.53	1.01	9.54	1.99
11	Narmada	6.6	16.72	23.32	0.47
12	Mahi	4.75	0.36	5.11	0.02
13	Sabarmati	1.35	0.12	1.47	0.09
14	West Flowing Rivers of Kachchh and Saurashtra including Luni.	4.31	0.58	4.89	3.15
15	West Flowing Rivers south of Tapi	17.34	4.97	22.31	2.54
16	East Flowing Rivers Between Mahanadi and Godavari.	1.63	1.45	3.08	0.86
17	East Flowing Rivers Between Godavari and Krishna.				
18	East Flowing Rivers Between Krishna and Pennar.				
19,20	East Flowing Rivers Between Pennar and Cauvery and south of Cauvery	1.42	0.02	1.44	NA
21	Area of North Ladakh not draining into Indus	NA	NA	NA	NA
22,23	Rivers draining into Bangladesh and Myanmar	0.31	0	0.31	NA
24	Drainage areas of Andman, Nicobar and Lakshadweep Islands.	NA	NA	NA	NA
	Total	173.71	75.43	249.14	132.32
	Say	**174**	**76**	**250**	**132**

Source: Storage in River Basins of India - CWC 1997, MOWR, GOI, New Delhi.

Note : Projects having a live storage capacity of 10 Mm^3 and above only are included. An additional live storage capacity of 3 Km^3 (approximate) is estimated to be created through medium projects each having a capacity of less than 10 Mm^3, thus making a total live storage capacity of 177 Km^3 in completed projects.

Central Water Commission estimated the utilisable surface water in each river basin considering the suitable sites/locations for diversion and storage structures to achieve the ultimate irrigation potential of 76 Mha and to satisfy demands of domestic, industrial and other sectors by 2025. Total utilisable flow in the river basins was estimated as 690.31 km^3. The basin wise distribution of utilisable surface water is shown in Table 3.6.

Table - 3.6
Average Flow and Utilisable Surface Water - Basinswise

Unit : Km^3 / Year

S.No.	River Basin	Water Resource	Utilisable Surface Water
1	2	3	4
1	Indus	73.31	46
2	Ganga-Brahmaputra-Meghna Basin		
2a	Ganga sub-basin	525.02	250
2b	Brahmaputra sub-basin	629.05	24
2c	Meghna(Barak) sub-basin	48.36	
3	Subaranrekha	12.37	6.81
4	Brahmani-Baitarani	28.48	18.3
5	Mahanadi	66.88	49.99
6	Godavari	110.54	76.3
7	Krishna	69.81	58
8	Pennar	6.32	6.86
9	Cauvery	21.36	19
10	Tapi	14.88	14.5
11	Narmada	45.64	34.5
12	Mahi	11.02	3.1
13	Sabarmati	3.81	1.93
14	West Flowing Rivers of Katchchh and Saurashtra including Luni.	15.1	14.98
15	West Flowing Rivers south of Tapi	200.94	36.21
16	East Flowing Rivers Between Mahanadi and Godavari.	17.08	13.11
17	East Flowing Rivers Between Godavari and Krishna.	1.81	
18	East Flowing Rivers Between Krishna and Pennar.	3.63	
19	East Flowing Rivers Between Pennar and Cauvery.	9.98	16.73
20	East Flowing Rivers south of Cauvery.	6.48	
21	Area of North Ladakh not draining into Indus	0	NA
22	Rivers draining into Bangladesh	8.57	NA
23	Rivers draining into Myanmar.	22.43	NA
24	Drainage areas of Andman, Nicobar and Lakshadweep Islands.	0	NA
	Total	1952.87	690.32

Source:
1)Reassessment of Water Resources Potential of India - CWC, Publication 6/93, MOWR, GOI.
2)Water Resources of India, CWC, 30/88.

DISTRIBUTION OF NUMBER OF DAMS IN THE COUNTRY

State	Completed	Under Construction	Total
Maharashtra	1229 (34%)	300 (43%)	1529 (36%)
Madhya Pradesh	946 (26%)	147 (21%)	1093 (25%)
Gujarat	466 (13%)	71 (10%)	537 (13%)
Other States	955 (27%)	177 (26%)	1132 (26%)
Total	**3596**	**695**	**4291**

Note : *Figure in the bracket is percentage of total under the column.*
Source : *Water and Related Statistics, CWC (1998).*

For lack of adequate storage sites on the Ganga in its catchment in India, the available flows cannot be fully used and there is a surplus in the river in the monsoon period. The Brahmaputra basin is very narrow and there is limited land available for irrigation. Besides, storage sites are limited. This has resulted in enormous quantity of surplus flows in this river. Similarly, in west flowing rivers of Kerala, Karnataka, Maharashtra and Gujarat states, there is limited land available for irrigation and the rivers are small in length. The flows of Mahanadi and Godavari cannot also be fully utilised. The utilisable flows in Pennar, East flowing rivers between Pennar and south Cauvery as reported are more than annual flows in the basins. A possible reason for this anomaly may be double counting of return flows and the recharge to the ground water.

We have adopted utilisable flows in various basins as assessed by CWC by conventional schemes. It should be noted, however, that sedimentation in the reservoirs causes reduction in the storage capacity. Loss of about 65 km^3 storage capacity has been estimated in the total projected reservoir capacity of 382 km^3 due to sedimentation by the year 2050. The impact of 65 km^3 loss in total reservoir capacity on utilisable surface water resource of 690.3 km^3 may be the reduction in the utilisable surface water resource approximately by a similar amount by the year 2050.

There is scope for increasing the utilisation in Ganga – Brahmaputra by construction of storages at suitable locations in neighbouring countries through bilateral agreements. It is also possible to enhance the estimated utilisable water through proper regulation of reservoirs and by providing carry over storage. We suggest that the CWC should carry out studies to revise estimates of utilisable flows in each river basin/sub-basin/state.

To enhance the utilisable flows, it is imperative to look for other possibilities such as:

- Artificial recharge of ground water to increase the ground water potential.
- Inter-basin water transfers wherever feasible.
- Recycling and reuse of water.
- Desalinisation of saline water.
- Water harvesting, watershed development and revival of traditional water storage structures.

CGWB has prepared a National Perspective Plan (1996) for Recharge of Ground Water by utilising surplus monsoon run-off in river basins, on the basis of availability of surplus monsoon run-off and sub-surface storage potential.

The Ministry of Irrigation (now Water Resources) had formulated a National Perspective for Water Resources Development in August, 1980. It has two components viz. (1) Himalayan Rivers Development; and (2) Peninsular Rivers Development. The inter-basin transfer proposals envisage additional utilisation of 200-250 km^3 of water to bring additional area of 35 Mha under irrigation.

The utilisable flows (690 km^3) estimated earlier were based on prevailing irrigation efficiency, delta and scale of production of crops. It is likely that there may be surplus water in a few basins out of estimated utilisable flows after meeting the projected demands of the basins for different uses in case of improvement in irrigation efficiency, reduction in delta and enhanced production of food crop per unit of area with proper water management by 2050 and the same can be considered for utilisation outside the basin. The details of major east flowing Peninsular river basins are discussed later in Chapter 7 on "Inter-Basin Transfers".

However, these proposals have to be firmed up after detailed studies including availability of arable land for irrigation and the cost of pumping.

The possibilities of augmenting water resources through construction of reservoirs in upper-neighbouring countries, recycling and desalinisation are discussed later in the Report.

3.4 Ground Water Resource and Utilisation

Ground water is widely dispersed. It is an important source of water for drinking and irrigation. It accounts for more than 45 percent of the total irrigation in the country. The contribution of ground water to achieve self-sufficiency in foodgrain production in the past three decades has been remarkable. In the coming years, the ground water utilisation is likely to increase manifold for expansion of irrigation and for meeting growing needs of domestic and industrial uses due to vast growth of population and urban centres. The increasing use of ground water is due to the ease and simplicity with which it can be extracted. Technology developments in pump manufacture and in deep well drilling have given boost to ground water extraction. Ground water pumping by individuals/farmers has proliferated. Unfortunately, it is particularly more intensive in those very areas where it should be restricted for maintaining ground water levels for ecological and environmental considerations. For planned development of ground water, both dynamic and static ground water resources, its quantity and quality assessment in space and time is a pre-requisite. As per the National Water Policy, development of ground water resources is to be limited to utilisation of replenishable component of naturally occurring ground water available in sub-surface domain.

The first assessment of the total water resources made by Dr. A.N. Khosla in 1949 at 1,673 km^3 did not give separate estimate of ground water resource. The National Commission on Agriculture (1976) estimated the ground water resources at 350 km^3 , of which 260 km^3 was considered as available for irrigation. The Ground Water Over-Exploitation Committee (1979), constituted by Agriculture Refinance and Development Corporation (ARDC), estimated the ground water potential as 467.9 km^3. The Ground Water Estimation Committee (1984) suggested in its report a suitable methodology for estimation of ground water resources. The Working Groups constituted in different states estimated block/districtwise total ground water resource as 453.3 km^3, based on the norms of the Ground Water Estimation Committee.

The norms set up by this committee are currently being utilised by Central Ground Water Board (CGWB) and State Ground Water Departments to estimate the ground water resource. Replenishable Ground Water Resource was estimated by the Working Groups (constituted in 1994-95) based on large volume of hydrogeological and related data generated by CGWB and State Ground Water Organisations and the existing knowledge of ground water regime as 431.9 km^3. This is the sum total of potential due to natural recharge from rainfall (342.4 km^3) and the potential due to recharge augmentation from canal irrigation system (89.5 km^3) . After allowing a minimum of fifteen percent of this quantity for drinking and industrial purposes, the remaining can be utilised for irrigation purposes. The available ground water resource for irrigation is 360.8 km^3 of which utilisable quantity is taken as 324.7 km^3[$] . The estimates by CGWB of total replenishable ground water resource, provision for domestic, industrial and irrigation uses and utilisable ground water resources for future use are given in Table 3.7 below :

Table-3.7

Ground Water Resource

1.	Total Replenishable Ground Water Resource	432 km^3
2.	Provision for Domestic, Industrial & Other Uses	71 km^3
3.	Available Ground Water Resource for Irrigation	361 km^3
4.	Utilisable Ground Water Resource for Irrigation (90 percent of the Sl. No.3)	325 km^3
5.	Total Utilisable Ground Water Resource (Total of Sl. No. 2 & 4)	396 km^3

Source: Ground Water Resources of India, CGWB, 1995.

The statewise estimates of dynamic ground water (fresh) resource made by the CGWB are given in Table 3.8.

$ Only fresh water resources are accounted for in the assessment of ground water resources and saline water is excluded.

Table - 3.8

Dynamic Fresh Ground Water Resource-Statewise

S.No.	States	Total Replenishable Ground Water Resource from Normal Natural Recharge	Total Replenishable Ground Water Resource Due to Recharge Augmentation from Canal Irrigation	Total Replenishable Ground Water Resource	Contribution from Recharge Augmentation from Canal Irrigation to Total Ground Water Resource
		km^3 per year	km^3 per year	km^3 per year	%
1	**2**	**3**	**4**	**5**	**6**
1	Andhra Pradesh	20.03	15.26	35.29	43
2	Arunachal Pradesh	1.44	0.00	1.44	0
3	Assam	24.23	0.49	24.72	2
4	Bihar	28.31	5.21	33.52	16
5	Goa	0.18	0.03	0.21	14
6	Gujarat	16.38	4.00	20.38	20
7	Haryana	4.73	3.80	8.53	45
8	Himachal Pradesh	0.29	0.08	0.37	22
9	Jammu & Kashmir	2.43	2.00	4.43	45
10	Karnataka	14.18	2.01	16.19	12
11	Kerala	6.63	1.27	7.90	16
12	Madhya Pradesh	45.29	5.60	50.89	11
13	Maharashtra	33.40	4.47	37.87	12
14	Manipur	3.15	0.00	3.15	0
15	Meghalaya	0.54	0.00	0.54	0
16	Mizoram	Not Assessed			
17	Nagaland	0.72	0.00	0.72	0
18	Orissa	16.49	3.52	20.01	18
19	Punjab	9.47	9.19	18.66	49
20	Rajasthan	10.98	1.72	12.70	14
21	Sikkim	Not Assessed			
22	Tamil Nadu	18.91	7.48	26.39	28
23	Tripura	0.57	0.10	0.67	15
24	Uttar Pradesh	63.43	20.39	83.82	24
25	West Bengal	20.30	2.79	23.09	12
26	Union Territories	0.35	0.05	0.40	13
	Total	**342.43**	**89.46**	**431.89**	21

Source: Ground Water Resources of India, CGWB, 1995.

The Central Ground Water Board makes the estimates of ground water by administrative units, i.e. blocks, districts and states. We have redistributed and readjusted these estimates to obtain basin wise estimates of ground water. It may be noted that further approximation is involved in this exercise. The basinwise distribution of dynamic ground water is shown in Table 3.9.

Table - 3.9
Dynamic Fresh Ground Water Resource -Basinwise

Unit : Km^3 / Year

S. No.	River Basin	Total Replenishable Ground Water Resource	Total Replenishable Ground Water Resource Due to Recharge Augmentation From Canal Irrigation	Total Replenishable Ground Water Resource From Normal Natural Recharge
1	2	3	4	5
1	Indus	26.5	12.21	14.29
2	Ganga-Brahmaputra-Meghna Basin			
2a	Ganga sub-basin	171.57	35.1	136.47
2b	Brahmaputra sub-basin	26.55	0.83	25.72
2c	Meghna (Barak)sub-basin	8.52	0	8.52
3	Subarnarekha	1.8	0.12	1.68
4	Brahmani-Baitarani	4.05	0.7	3.35
5	Mahanadi	16.5	2.86	13.64
6	Godavari	40.6	7.12	33.48
7	Krishna	26.4	6.52	19.88
8	Pennar	4.93	0.89	4.04
9	Cauvery	12.3	3.51	8.79
10	Tapi	8.27	1.6	6.67
11	Narmada	10.8	1.42	9.38
12	Mahi	4	0.5	3.5
13	Sabarmati	3.2	0.3	2.9
14	West Flowing Rivers of Kachahh and Saurashtra incldiung Luni.	11.2	2.1	9.1
15	West Flowing Rivers south of Tapi	17.7	2.15	15.55
16	East Flowing Rivers Between Mahanadi and Godavari.			
17	East Flowing Rivers Between Godavari and Krishna.	18.8	5.98	12.82
18	East Flowing Rivers Between Krishna and Pennar.			
19	East Flowing Rivers Between Pennar and Cauvery	18.2	5.55	12.65
20	East Flowing Rivers south of Cauvery			
21	Area of North Ladakh not draining into Indus	Not Assessed		
22	Rivers draining into Bangladesh	Not Assessed		
23	Rivers draining into Myanmar.	Not Assessed		
24	Drainage areas of Andman, Nicobar and Lakshadweep Islands.	Not Assessed		
	Total	**431.89**	**89.46**	**342.43**

Source: See text.

It may be seen (Table 3.8) that in keeping with the hydrogeological variations in the country, the ground water development potential, too, varies widely in different states/regions. Though rainfall has been the principal source for ground water recharge, the recharge from canal seepage and return flow of irrigation has also been significant for estimating ground water resource in some states. The contribution from canal system to the annual ground water recharge in the States of Andhra Pradesh, Punjab, Haryana and Jammu & Kashmir ranges from 43 percent to 49 percent while in the States of Tamil Nadu and Uttar Pradesh, it is 24 percent to 28 percent; in other states, it is meagre.

Ground water extraction has become a common phenomenon with individuals putting pumping structures to tide over shortage of water supply by local bodies. This trend has been accentuated by the unplanned growth of urban centres. On the basis of the stage of ground water development, block-wise categorisation of exploitation is made in terms of over exploited, dark, grey and white zones representing more than 100 percent, 85 to 100 percent, 65 to 85 percent and less than 65 percent exploitation. Such classification should be kept in mind while developing ground water resources in different areas.

The CGWB should carry out further studies for verification and estimation of various parameters that are being used for the assessment of ground water resources and revise the assessment.

GROUND WATER OVER EXPLOITED BLOCKS

State	Number of Blocks	Over Exploited		Level of Ground Water Development, %
		Number	%	
Punjab	118	62	52.54	94
Haryana	108	45	41.67	84
Rajasthan	236	45	19.07	51
Tamil Nadu	384	54	14.06	61
Gujarat	218	14	06.42	42
Karnataka	175	06	03.43	31
Uttar Pradesh	895	19	02.12	38
Andhra Pradesh	309	02	00.65	24
Other States	2722	Nil	Nil	-
Total	**5165**	**247**		**-**

Note : Unit in Andhra Pradesh is Mandal; in Gujarat, it is Taluka and in Maharashtra, it is Watershed. 1104 Mandals in Andhra Pradesh are equivalent to 309 blocks, 184 Talukas in Gujarat are equivalent to 218 blocks and 1503 Watersheds in Maharashtra are equivalent to 366 blocks. Total includes equivalent blocks in 3 states.

Source: Ground Water Resources of India, CGWB, 1995.

3.5 Static Ground Water Resource

The static fresh ground water resource is considered as ground water available in the aquifer zones below the zone of water level fluctuation. The computation of static ground water resources may be made after delineating the aquifer thickness and specific yield of the aquifer material. The process can be explained as follows:

Static Ground Water Reserve = {Thickness of the aquifer below the zone of water level fluctuation down to exploitation limit} X {Areal extent of the aquifer} X {Specific Yield of the aquifer}

Preliminary studies indicate that in alluvium, ground water can be exploited down to 450 m, as in the Indo-Gangetic valley. The coastal aquifers are also having similar depth range of ground water availability. Inland river basins in the country have recorded shallower depth within the range of 100 – 150 m. In Gondwana Territories of Maharashtra and Andhra Pradesh, ground water can be extracted upto the depth range of 175 – 250 m. In hard rock terrain, the availability of ground water increases steadily upto around 100m whereafter the frequency of water yielding fractures diminishes except in sporadic cases.

The general range of yield in the unconsolidated formations is from 200 – 350 m^3/hr. Some of the prominent water bearing strata in these formations are Piedmont alluvial Plain, Glaciolacustrine deposits, Inland river flood plains and coastal alluvium. In the Indo-Gangetic alluvial plain, tubewells were constructed upto the depth of 600 m with a yield prospect of 400 m^3/hr. In the semi-consolidated formations, the ground water productivity is fairly good. The lathi formation in western Rajasthan has recorded the highest yield of more than 450 m^3/hr at a depth of 544 m. The general yield range is 60 – 200 m^3/hr for depth of 250 – 400 m. The ground water prospects in the fractured rock formations in the peninsular India are nonhomogeneous and site specific. The yield of the borewells tends to decrease with increasing depth due to reduction in degree of weathering, closure of joints and fracture openings and lack of interconnection between fractures. However, in tectonically weaker zones in hard rock formations, the wells have recorded good yield. The average range of well yield in these formations is from 50 to 150 m^3/hr at favourable locations.

An assessment of the quantum of Static Water resource available in the country has been carried out by CGWB on the basis of the depth of availability of ground water and the productivity of deeper aquifers. The estimate of static water resource has been made district wise in different states of the country. The total estimated static ground water resource is 10,812 km^3. The details are given below in Table 3.10.

Table - 3.10

Static Fresh Ground Water Resource-Statewise

S.No.	States	Static Fresh Ground Water Resource		
		Alluvium/Unconsolidated Rocks	Hard Rocks	Total
		km^3	**km^3**	**km^3**
1	**2**	**3**	**4**	**5**
1	Andhra Pradesh	76	26	102
2	Assam	920	0	920
3	Bihar	2557	11	2568
4	Gujarat	92	12	104
5	Haryana	420	1	421
6	Himachal Pradesh	13	0	13
7	Jammu & Kashmir	35	0	35
8	Karnataka	0	17	17
9	Kerala	5	6	11
10	Madhya Pradesh	14	27	41
11	Maharashtra	16	22	38
12	Orissa	162	13	175
13	Punjab	910	0	910
14	Rajasthan	115	13	128
15	Tamil Nadu	98	0	98
16	Tripura	101	0	101
17	Uttar Pradesh	3470	30	3500
18	West Bengal	1625	1	1626
19	Delhi	3	0	3
20	Chandigarh	1	0	1
	Total	**10633**	**179**	**10812**

Source: Report of Instorage Fresh Ground Water Resource of India 1999, CGWB (Unpublished)

Note: 1. In-storage Ground Water resources = Volume of aquifer zone x Specific yield.
2. The estimations are for aquifer zones below the zone of water table fluctuation.
3. The estimation pertains to depth of 450 m in alluvial terrain and 100 m in hard rock terrain.
4. The estimate is based on district wise ground water resources.

The above estimates have been adjusted to obtain basin wise estimates of static ground water resources as shown in Table 3.11.

Table - 3.11

Static Fresh Ground Water Resource -Basinwise

Unit : Km^3

S.No.	River Basin	Static Fresh Ground Water Resource		
		Alluvium/Unconso-lidated Rocks	Hard Rocks	Total
1	2	3	4	5
1	Indus	1334.9	3.3	1338.2
2	Ganga-Brahmaputra-Meghna Basin			
2a	Ganga sub-basin	7769.1	65	7834.1
2b	Brahmaputra sub-basin	917.2	0	917.2
2c	Meghna (Barak)sub-basin	101.3	0	101.3
3	Subarnerakha	10.1	0.7	10.8
4	Brahmani-Baitarani	40.1	3.3	43.4
5	Mahanadi	108.4	11.3	119.7
6	Godavari	36	23.4	59.4
7	Krishna	13.6	22.4	36
8	Pennar	3.9	7.2	11.1
9	Cauvery	39.1	3.3	42.4
10	Tapi	4.3	3.2	7.5
11	Narmada	13.8	4.6	18.4
12	Mahi	9.7	2.9	12.6
13	Sabarmati	25.5	2.7	28.2
14	West Flowing Rivers of Kachahh and Saurashtra including Luni.	103.1	10.1	113.2
15	West Flowing Rivers south of Tapi	5.4	5.8	11.2
16	East Flowing Rivers Between Mahanadi and Godavari.	34.4	6.9	41.3
17	East Flowing Rivers Between Godavari and Krishna.			
18	East Flowing Rivers Between Krishna and Pennar.			
19	East Flowing Rivers Between Pennar and Cauvery.	63.1	2.9	66
20	East Flowing Rivers south of Cauvery.			
21	Area of North Ladakh not draining into Indus	Not Assessed		
22	Rivers draining into Bangladesh	Not Assessed		
23	Rivers draining into Myanmar.	Not Assessed		
24	Drainage areas of Andman, Nicobar and Lakshadweep Islands.	Not Assessed		
	Total	**10633.00**	**179.0**	**10812.0**

Source: See text.

Note: 1. The estimates are for the aquifer zones below the zone of water table fluctuation.
2. In-storage ground water resource = Volume of aquifer zones x specific yield.

The Indo-Gangetic alluvial plain, with an area of around 25,000 km^2, is one of the largest ground water reservoirs of the world. The Oil and Natural Gas Commission and Oil India Limited have carried out seismic surveys, geological mapping and exploratory drilling. In 1986, a World Bank Consultant conducted a study on the depth of occurrence and thickness of fresh water aquifers, utilising the findings of ONGC. It was found that there are good prospects of encountering deep fresh water aquifers under very high hydrostatic pressure, which may be tapped as free flowing without any consumption of power. Accordingly, a proposal was formulated by the CGWB to explore the possibility of tapping the vast ground water resources existing in the deep aquifers in the Ganga basin. Proposed deep drilling should explore additional in-storage ground water reserve.

Depending upon annual recharge potential, aquifer characteristics and other relevent parameters, only a part of the static ground water resources could be planned for development and use on a temporary basis. Substantial part of static water resources should be reserved for use for drinking during the eventuality of extreme drought conditions. Since static ground water resoûrce has not been fully investigated, no part of the resource is included in the utilisable water resources of the country. It is necessary that the investigations are completed at the earliest, especially in drought prone areas.

The annual utilisable water from surface and ground resource are 690 Km^3 and 396 km^3 and total annual utilisable water resource is 1086 km^3 . Besides this, the quantity of 123 km ^{3}(low demand senario) to 169 km^3 (high demand senario) additional return flow will also be available from increased use from irrigation, domestic and industrial purposes in 2050 AD (refer Table 3.32).

II. Water Requirement

3.6 Diverse Uses of Water

Having made the estimates of availability of water resources, we now address the question of water requirements till year 2050.

Water is required for agriculture production, for drinking purposes by human beings and animals, for municipal and commercial uses. Water is an essential input for all industries. Energy and navigation development also require water. When water is stored, a part of it is lost by evaporation. Release of fresh water into water courses and water bodies is also some times essential to ensure minimum flow and to restore quality to acceptable standard. Water requirement for agricultural production and domestic needs including drinking, cooking, sanitation, and municipal services and for trade, commerce and industries, together constitute the bulk of the total water consumption. Requirement is closely related to population, demand for food, production of non-food agricultural and industrial items, production of energy, and for improvement in the quality of life and for preserving ecology of the nation.

According to available estimates, the total withdrawal/utilization for all uses in the year 1990 was 552 km^3 or 655 m^3/person /year (MOWR, 1997). Out of the total water utilised in the country, irrigation accounted for nearly 83 percent; followed by drinking and municipal use (4.5 percent), energy development (3.5 percent) and industries (3 percent). Other activities claimed approximately 6 percent of the total use.

3.7 Approaches to Estimating Water Requirement

The demand for water can be understood as the quantity of water required to be supplied for specific use. In other words, the demand includes consumptive as well as necessary non-consumptive water requirements of the user sector.

We have prepared estimates of water requirements for the years 2010, 2025 and 2050 at the national level. We have adopted a "building block approach". Water requirement for each important use is estimated, and then added up to obtain total water requirement. As will be shown below, several assumptions had to be made to arrive at the figure of total water requirement for the country as a whole. While estimating demand by different sectors, aspects of management and technology are given due consideration. Also, international and Indian norms and standards have been taken into account. Likely changes in technologies as well as in socio-economic environment have also been considered. State-wise and Basin-wise water requirements have also been made with some additional assumptions.

3.8 Water Requirement For Irrigation

Water requirement for irrigation is a derived demand. The key determining variables are:

- Requirement for food production,
- Requirement for non-food production,
- Efficiency of water use, and
- Productivity per unit of land.

We are of the view that food self sufficiency and to some extent export of food and non-food agriculture produce is essential for the country from both strategic and socio-economic considerations. The case for food self sufficiency has been propounded by several authors and rests mainly on four arguments; (I) unreliability of foreign source of food supply for a large country like India, (ii) foreign exchange constraints in case of large scale imports, (iii) potential of augmenting food supplies by improving existimg low yields, and(iv) income and employment considerations for the large workforce dependent on foodgrain production. The case of augmenting exports, especially of the so called commercial crops, rests on the comparative advantage this country has in production of several non-food agricultural commodities due to its diverse climate and land resources. The overriding consideration in estimation of water requirement for irrigation is self sufficiency in food production at national level. The Commission is also of the view that the present ratio of food and non-food productions in terms of area sown, that is 70:30 and 66:34 for irrigated and unirrigated cropped areas is sustainable from physical and socio-economic considerations.

Requirement of food production would mainly depend upon the country's population, per capita income and changes in dietary habits.

Population Growth : There are a number of estimates and projections of future population growth. We reviewed some of the important studies in this area, namely short and long-term population forecasts by Natarajan (1993), United Nations (1995, Revised estimates), Registrar General of India (RGI 1996) and Visaria.L and Visaria.P (1996) (See Table 3.12).

Table - 3.12

Population Projections by Different Scholars and Agencies

(in million)

S.No.	Reference	All India Population in Year					
		2000	2010	2016	2020	2025	2050
1	Natarajan (1993)*	1020.5	1183.1		1301		
2	United Nations -1994 Revision **						
	a. Low Variant	1013.5	1156.6		1249.7	1286.3	1345.9
	b. Middle Variant	1022	1189		1327.1	1392	1640
	c. High Variant	1030.5	1221.7		1406.1	1501.5	1980
3	Registrar General of India (1996)#	997	1162	1263.5			
4	Visaria & Visaria (standard) 1996##	995	1146			1333	1581

Source : * *Population Projections for India: Paper presented in the 17th Conference (16 December, 1993) of Indian Association for Study of Population by Natarajan K.S. at Annamalai University, Tamil Nadu.*

** *World Population Prospects - The 1994 Revision, United Nations, New York, 1995.*

Population Projections of India and States 1996-2016, Registrar General India, Census of India, Ministry of Home Affairs, GOI, New Delhi, 1996.

Visaria L. and Visaria P., Prospective Population Growth and Policy Options for India- 1991-2001, The Population Council, New York, 1996.

After examining the latest trends and the views expressed by different demographers, we decided to follow the higher and lower limits of India's population in the year 2050 corresponding to those estimated by Visaria and Visaria and United Nations (low variant) respectively, that is 1581 million and 1346 million.

Urban and rural populations have different life styles and, therefore, their needs for food and drinking water are now markedly different. It is, however, recognised that with access to information and demand for rural-urban equality, the gap between urban and rural demand for food is likely to shrink gradually. However, the differences will persist for a long time to come and therefore, separate estimates for rural and urban demand for food are warranted.

Urbanisation : Between 1951 to 1981, the rate of growth of India's urban population rose steadily from decade to decade. Based on this trend, it was expected that the urban population of about 159 million in 1981 would more than double by 2001. But the 1991 census showed that urban population was much lower than predicted. Since then, the earlier projections of India's urban population size have been consistently revised downwards.

The rate of natural population growth in urban areas declined from 2.0 per cent in 1981-85 to 1.7 per cent in 1992-94. Given the increasing acceptance of birth control methods in urban areas, a continuing decline in the urban rate of natural increase appears to be more likely. Besides, the deteriorating municipal services in urban India, rapidly increasing urban land prices and congestion on one hand, and the increasing availability of civic facilities in villages, along with improved commuting facilities between urban and rural areas, better infrastructure and explosion of information technologies are all likely to keep a check on the rural-urban migration. Keeping all these factors in view, we have estimated 646 million and 971 million as lower and upper estimates of urban population in the year 2050. A consolidated picture of the total population and its urban and rural segments is presented in the Table 3.13.

Table - 3.13

Projected Population and Urban and Rural Break-up

(in million)

Particulars	Population Size	Population in the Year					
		2010		2025		2050	
		High@	Low*	High	Low	High	Low
Population		**1146**	**1157**	**1333**	**1286**	**1581**	**1346**
Rural		759	790	730	810	610	700
Urban Total		387	367	603	476	971	646
Class I	>100,000	258.13	238.55	361.8	261.8	485.5	290.7
Other than Class I:							
Class II + III	20,000 - 100,000	90.17	88.08	150.75	119.00	242.75	193.80
Class IV - VI	<20,000	38.70	40.37	90.45	95.20	242.75	161.50
Total of Other than Class I		128.87	128.45	241.20	214.20	485.50	355.30

Source: *See text.*
@ As per Visaria & Visaria
** As per UN (Low Variant)*

Projection of Demand for Food : In 1990-91, India produced 176.4 million tonnes of foodgrains including 162.1 million tonnes of cereals and 14.3 million tonnes of pulses. The availability for human consumption after netting for seed, feed and waste and after accounting for imports and changes in stocks was around 145 million tonnes. In urban areas, cereal consumption seems to have stabilized at about 135 kg per capita per year, while it has actually declined in rural areas from 185 to 175 kg per capita per year during the last two decades. Diets have become more diversified with increasing shares of the food budget allocated to milk, eggs and livestock products. Milk consumption, in particular, has grown very fast, averaging about 6 per cent per year in recent years.

The average household still spends about 60 per cent of its total budget on food with cereals accounting for about 35 per cent of this share. The small amount of cereals fed to livestock reflects low budget shares for livestock products, and also a high reliance on crop by-products, household waste, and open grazing for feeding livestock. Cereal demand has not grown as rapidly in recent years as many experts had previously expected. Several studies had predicted that total cereal demand in India will exceed 200 million tonnes/year by year 2000. In 1998-99, the country had reached the level of 200 million tonnes, with no appreciable shortage at macro level. The Commission, therefore, wanted to examine the likely demand for food for the year 2050 in some what greater detail. Apart from the estimates prepared by Bhalla and Hazel for their ongoing study on "Prospects for Balancing Food Needs with Sustainable Resource Management" (under the auspices of the International Food Policy Research Institute-IFPRI), the Commission sponsored a special study on food demand projection by C. Ravi.

These demand projections, namely the one by G.S.Bhalla and Peter Hazel and the other by C. Ravi have been examined in detail by us. Bhalla and Hazell have made projections of food-demand upto year 2020. They have considered alternative scenarios for income growth, livestock feeding practices, and reduction in poverty. The study also made certain assumptions about population growth, the rate of urbanization, and consumer's expenditure elasticities. The study considered three scenarios viz. (i) projection of current trends, (ii) impact on demand for food by bringing all the poor above the poverty line and (iii) impact on the demand for food if everyone among the malnourished were to become well-fed. Using the results of 1987/88 National Sample Survey of consumer expenditure, the consumption basket of all expenditure groups falling below the poverty line was increased to the consumption basket of the group lying just above the poverty line. Recognizing that over one third people living above the official poverty line are still malnourished, particularly from protein deficiency, a third scenario considered every one among the malnourished to become well fed. In this scenario, food consumption basket recommended by the Indian Council of Medical Research (ICMR) was considered as the desired minimum. Again, using 1987/88 NSS consumer expenditure data for urban and rural households, the consumption expenditure for all expenditure groups were increased to match the ICMR norms and then revised estimates were prepared for the population as a whole.

Since long-term estimates for food-demand, extending beyond year 2020 were not available, C. Ravi considered the aggregate demand for food as a function of population, urbanization, economic growth and expenditure distribution. Three scenarios of economic growth rate namely economic growth at 4 percent, 4.5 percent and 5 percent per capita per year were considered. We found the assumption of the growth rate of 4.5 percent per capita per year as reasonable.

There are some differences in the methodology adopted by Bhalla and Hazel and that by C. Ravi. However, they are broadly comparable. The results of these twostudies and their various scenarios are summarised in Table 3.14.

Table - 3.14

Comparison of Long Term Food Demand Estimates

(Food Demand in kg per capita per year)

Study	Years					
	1990-9	1993-9	2010	2020	2025	2050
Bhalla & Hazel						
Assumptions on:						
(a) Urbanisation (in %)	26			42		
(b)Growth rate of agg. expenditure (in%)				5		
Food and Feed Demand:						
Base line	175			270		
Poverty Removal scenario	183			285		
Well-fed India scenario	173			278		
C.Ravi						
Urbanisation (in %)	26		32		37	46
Growth rate of agg. expenditure (in%)			4		4	4
Food and feed Demand		168	189		210	258
Growth rate of agg. expenditure (in%)			4.5		4.5	4.5
Food and feed Demand			194		218	284
Growth rate of agg. expenditure (in%)			5		5	5
Food and feed Demand			198		228	321

Source : * *"Foodgrain Demands in India to 2020- A preliminary Exercise", G.S.Bhalla and Peter Hazel Vol.XXXII, No.52,Economic and Political Weekly, 1998, Mumbai.*
"Food Demand Projections For India", Study By C. Ravi, 1998 (Unpublished).

In view of the recent trends in food consumption and considering socio-economic factors, the Commission has accepted the food and feed demand projected by Ravi with yearly growth rate 4.5 per cent per capita expenditure. This amounts to 194, 218 and 284 kg of foodgrains per head per year for the years 2010, 2025 and 2050 respectively.

Using the high and low population projections for the country (see Table 3.13) and per capita per annum food requirement discussed above, the total food requirement for the country has been estimated between 449 Million Tonnes (High Demand Scenario) and 382 Tonnes (Low Demand Scenario). Feed requirement, losses in storage & transportation, seed requirement and carry over for years of monsoon failure in the country have been estimated at 12.5 percent, of the foodgrain production. The consolidated picture is presented in Table 3.15.

Table - 3.15

Projected Foodgrain and Feed Demand

(in million tonnes)

Demand	Years		
	2010	2025	2050
High Demand	224	291	449
Low Demand	222	280	382
With addition of seed, feed, wastage etc.			
High Demand	247	320	494
Low Demand	245	308	420

Source: See text.

Projected Land Use: With the goal of food self-sufficiency at macro level, the demand estimates were converted into the domestic supplies, the latter being a factor of arable area and yield per hectare. Out of total geographical area of 328.73 Mha of the country, the land area is only 297.319 Mha. Following is the land use pattern for the latest available year (See Table 3.16) :

Table - 3.16

Land Use Pattern for the Year 1993-94

(in 1000 ha)

S.No.	Particulars	Area
1	Total Geographical area	328726
2	Reporting area	300358
3	Forest	68421
4	Area not available for cultivation:	
	a.Area put to non-agricultural uses	22035
	b.Barren and Unculturable	18975
5	Other uncultivated land excluding Fallow Lands	
	a.Permanent Pastures and other grazing lands	11176
	b.Land under miscellaneous tree crops & Grooves not included in Net Sown Area.	3657
	d. Culturable Waste Land	14468
6	Fallow Lands:	
	a.Fallow lands other than current fallows	9703
	b.Current Fallows	14333
7	Net Sown Area	142095

Source : Ministry of Agriculture, Directorate of Economics & Statistics, New Delhi

In the year 1993-94, forests and permanent pastures covered 68.4 Mha or 23 percent and 11.2 Mha or 3.8 percent of the land area respectively. Other non-agriculture uses accounted for 47.769 Mha or 16 percent of land area. The total cultivable area was 184.256 Mha or 62 percent of the land area (This is 12.7 percent of world's cultivable area of 1447.509 Mha). The total net sown area of the country has gradually increased from 118.75 Mha in the year 1950-51 to 140.27 Mha in the year 1970-71. Since then the net sown area has been fluctuating between 140 to 142.5 Mha. The gross cropped area has increased from 131.89 Mha in the year 1950-51 to 186.42 Mha in the year 1990-91. The gross sown area to net sown area or cropping intensity in the year 1992-93 was 130 percent.

Arable Land and Irrigated Area 1994
Country Comparison

Unit : 1000 ha

S.No.	Country	Geographical Area	Arable Land	Irrigated Area 1989	Irrigated Area 1994
1.	Australia	7,71,336	47,000 F	1,833 F	2,140 F
2.	China	9,59,696	92,516 F	45,349	49,368
3.	Egypt	1,00,145	3,110 F	2,571	3,500
4.	India	3,28,759	1,66,100 F	44,853	48,000 F
5.	Pakistan	79,610	20,800 F	16,890	17,150 F
6.	USA	9,36,352	1,85,742 F	20,600	21,400 F
7.	World	1,33,81,569	13,45,318	2,35,928	2,49,549

Source : FAO Year Book 1995 ; FAO estimates

Note : Latest figures are said to indicate that India ranks first in irrigated area.

Irrigation Development: Increase in gross cropped area is mainly due to expansion of irrigation. The gross irrigated area has increased from 22.6 Mha in the year 1950-51 to 68.4 Mha in the year 1993-94. The area irrigated from surface water was 30.87 Mha or 45 percent of the total irrigated area. Thus, out of the increase of 54.53 Mha in gross cropped area, nearly 84 percent or 45.8 Mha could have been due to additional irrigation facility.

As regards progress of irrigation development in the country is concerned, the same is reported in three different forms i.e. Irrigation Potential Created, Irrigation Potential Utilised and Irrigation by Source. While the figures of Irrigation Potential Created and Utilised are reported by the Ministry of Water Resources, the figures of Irrigation by Source are reported with other land use data by the Ministry of Agriculture. There are significant differences in the figures so reported probably due to difference in their definitions and methods of data collection and reporting as would be evident from the following status for the year 1993-94 :

Table - 3.17

Irrigation Development According to Different Sources of Information

(1993-94) **(in 1000 ha)**

Data	Surface Water	Ground Water	Total
i) Irrigation Potential Created	43271 (140 percent)	41506 (110 percent)	84777 (124 percent)
ii) Irrigation Potential Utilised	37534 (124 percent)	38579 (103 percent)	76113 (111 percent)
iii) Irrigation as per Land Use Statistics	30869 (100 percent)	37498 (100 percent)	68367 (100 percent)

Source: Water and Related Statistics ,CWC, MOWR, New Delhi, July, 1998.

The figures of total Irrigation Potential Created and Irrigation Potential Utilised as reported by Ministry of Water Resources are 124 and 111 percent of those of Irrigation by Source as reported by Ministry of Agriculture. Large inconsistency is seen in data at state level.

Further, there is a time lag of, say 3-4 years, between reporting of above data by the Ministry of Water Resources and Ministry of Agriculture. While the latest figures of Irrigation Potential Created and Utilised are reported for the year 1996-97, those of Irrigation by Source are reported for the year 1993-94.

While projecting requirements, we have used figures of Irrigation by Source for the year 1993-94 as base line data.

Ultimate irrigation potential of the country is estimated at 140 million hectares, out of which 75.9 Mha would be from surface water and 64.1 Mha from ground water source. At that level irrigation from surface and ground waters would be 54.3 and 45.7 percent of total irrigated area.

India which was an importer of foodgrains till the 1960s, has become not only self-sufficient but emerged as a marginal exporter of foodgrains in recent years. The production of foodgrains increased from 51 million tonnes in 1950-51 to 200 million tonnes in 1998-99. It is estimated that increase in irrigation facililities alone has contributed to about 52 percent increase in foodgrains production. Improved input management and agriculture practices and high yielding varieties have contributed to 48 percent increase in additional foodgrains production (See Table 3.18).

Cropping Pattern: In general cropping pattern in the country has witnessed important changes. Among foodgrains, from 1950-51 to 1992-93, area under wheat has increased by six percent, while areas under jowar, barley and gram have decreased. Among non-food crops, areas under sugarcane, fruits and vegetables and oilseeds have increased by one, two and six percent respectively over the same period.

Although there have been significant changes in the proportion of area under various foodgrains, the ratio of area under foodgrains and non-foodgrains has remained more or less static at 2:1. The area under foodgrains was 67 percent of the total cultivated area of 186.45 Mha in the year 1993-94 . It is assumed that the same proportion will continue through the reference period.

Table - 3.18

Contribution of Irrigation in Increase in Foodgrains Production Between 1950-51 to 1993-94

S.No.	Particulas	Unit	Quantity
1	Gross sown area under all crops - 1993-94	Mha	186.4
2	Gross sown area under foodgrains crops - 1993-94	Mha	124.7
3	Gross Irrigated area under all crops - 1993-94	Mha	68.4
4	Gross Irrigated area under foodgrains crops - 1993-94	Mha	48.247
5	Gross unirrigated area under foodgrains crops - 1993-94	Mha	76.453
6	Gross sown area under all crops - 1950-51	Mha	131.9
7	Gross sown area under foodgrains crops - 1950-51	Mha	97.3
8	Gross Irrigated area under all crops - 1950-51	Mha	22.6
9	Gross Irrigated area under foodgrains crops - 1950-51	Mha	18.317
10	Gross unirrigated area under foodgrains crops - 1950-51	Mha	78.983
11	Increase in irrigated area between 1950-51 to 1993-94	Mha	29.93
12	Foodgrains Yield under irrigated condition - 1993-94	t/ha	2.33
13	Contribution of foodgrains from additional irrigation	Tonnes	69.7
14	Foodgrain Production 1950-51	Tonnes	50.8
15	Foodgrain Production 1993-94	Tonnes	185
16	Increase in Foodgrain Production between 1950-51 to 1993-94	Tonnes	134.2
17	Percentage contriburion of irrigated area in foodgrains production	%	52.0

Source: Water and Related Statistics, Central Water Commission, MOWR, July, 1998

Out of total irrigated area of 68.4 Mha in 1993-94, 48.247 Mha or 70 percent was under foodgrain crops.This 70 percent is made of areas under rice, wheat, other cereals and pulses at 30, 31, 5 and 4 percent respectively. An average of 79 percent of the rice cropped area is irrigated in the country as a whole. However, percentage of irrigated area to total cropped area under rice varies from 14 to 100 amongst states; highest nearly 100 percent, being recorded in Haryana, Punjab, Andhra Pradesh and Tamil Nadu. Most of the total cropped area (81-84 percent) under wheat and barley is irrigated. Bihar (20 percent), Karnataka (35.7 percent), and Tamilnadu (13 percent) have less than 50 percent of area of wheat under irrigation. The average total rainfed (unirrigated) cropped area in 1993-94 was 118.18 Mha, out of which area under foodgrain crop was 77.317 Mha. The percentage of foodgrain area to total rainfed cropped area was 66 percent.

Land Use Projections: Taking into account the available land and water resources, and trends in cropping pattern, the Commission has made following assumption to estimate water requirement for irrigation:

Table - 3.19

Land Use Projections for Estimation of Food Production Under Two Scenarios (High Demand Scenario and Low Demand Scenario)

S.No.	Particulars	Year 2010	Year 2025	Year 2050
1.	Net Area Sown - Mha	143.0	144.0	145.0
2.	Cropping Intensity - percent	135	140-142	150-160
3.	Percent of Irrigated to Gross Cropped Area	40-41	45-48	52-64
4.	Percent of Irrigated Foodcrops Area to Gross Irrigated Area	70	70	70
5.	Percent of Rainfed Foodcrops Area to Gross Rainfed Cropped Area	66	66	66
6.	Percent of Surface Water Irrigation to Total Irrigation	47	49-51	54.3

Note: *1. Food crop area includes area under all food-equivalents i.e. horticulture, etc.*
2. The range against several rows depict the low and high values corresponding to Low Demand and High Demand cenarios.

Current Foodgrain Yields and Yield Potential: Statewise land use, irrigation and foodgrain production figures are available for 1993-94 and are shown in Table 3.20.

Table - 3.20

Statewise Land Use, Irrigation and Foodgrain Production - Year 1993-94

S. No	States	Sown Area			Irrigated Area			Net Irrigated to Net Sown area	Foodgrain Production Year 1996-97		
		Gross	Net	Gross to Net	Gross	Net	Gross to Net		Produ-ction	Area	Yield
		1000 ha	1000 ha	%	1000 ha	1000 ha	%	%	1000 t	1000 ha	t/ha
1	2	3	4	5	6	7	8	9	10	11	12
1	Madhya Pradesh	24829	19740	126	5529	5346	103	27	19565	14281	1.370
2	Maharashtra	21361	18021	119	3262	2680	122	15	14548	13793	1.055
3	Uttar Pradesh	25545	17250	148	16364	11564	142	67	42429	20471	2.073
4	Rajasthan	19254	16232	119	5595	4597	122	28	13045	12892	1.012
5	Andhra Pradesh	12688	11041	115	5052	3890	130	35	12628	6947	1.818
6	Karnataka	12432	10790	115	2971	2327	128	22	9335	7406	1.260
7	Gujarat	10672	9391	114	3087	2540	122	27	4943	3894	1.269
8	Bihar	9748	7267	134	4212	3453	122	48	13813	9339	1.479
9	Orissa	9747	6303	155	2510	2090	120	33	4786	8653	0.553
10	Tamil Nadu	7158	5901	121	3544	2799	127	47	7529	4203	1.791
11	West Bengal	8680	5459	159	2491	1911	130	35	12885	6039	2.134
12	Punjab	7623	4214	181	7238	3927	184	93	21566	5691	3.789
13	Haryana	5815	3513	166	4515	2663	170	76	11369	4057	2.802
14	Assam	3817	2706	141	572	572	100	21	3676	2853	1.288
15	Kerala	3042	2238	136	413	324	127	14	873	481	1.815
16	Jammu & Kashmir	1080	736	147	444	312	142	42	1687	845	1.996
17	Himachal Pradesh	975	572	170	171	100	171	17	1538	911	1.688
18	Tripura	460	277	166	60	35	171	13	N.A.	N.A.	N.A.
	All India	**186420**	**142095**	**131**	**68367**	**51452**	**133**	36	198170	123988	1.598

Source: *Water and Related Statistics, CWC, MOWR, New Delhi, July, 1998.*

It may be noted that yields of crops at a specific location depend not only on input management, cultural practices and seed varieties, but also upon rainfall and irrigation. Yields of various crops significantly differ from state to state, as shown in the Table 3.21.

Table - 3.21

Statewise Average Yields of Various Food Crops - 1993-94

(in kg/ha)

S.N.	State		Yields, kg/ha									
			Rice		Wheat		Jowar		Bajra		Gram	
			Irr	U.I.	Irr	U.I.	Irr	U.I.	Irr	U.I.	Irr	U.I.
1	Andhra Pradesh	Kharif	2522	1420			3020	757	1563		725	
		Summer	2994				2070	628				
2	Assam	Autumn	2042	1114	2277	1368						
		Winter	1509	1391								
		Summer	2161	1240								
3	Bihar	Autumn	960	603	1885	1382						852
		Winter	1110	616								
		Summer	1535									
4	Gujarat		1889	1138	3104	738	1431	907	1599	1216	1077	654
5	Haryana		2801		3668	2186	508	320	1502	1151	1314	790
6	Karnataka	Kharif	2783	1710	1432	526	2494	1203	1175	573	571	468
		Rabi	2064				1305	768				
		Summer	3018									
7	Kerala	Winter	2341	2041								
8	Madhya Pradesh	Autumn	1636	1164	2262	965		1073	1161	948	939	1100
9	Maharashtra	Summer	1852	1587	1696	871	1046	525	1437	919	794	699
10	Orissa	Winter	1870	1495								
11	Punjab	Autumn	3522	1593	4072	2256			1311	915	1296	878
12	Rajasthan	Kharif	1786	794	2570	1022			924	519	998	630
13	Uttar Pradesh											
14	West Bengal	Summer	2950	2583	2248	1670					1009	973
15	Tamil Nadu		3206		-		2251	1015	2653	1336		

Source: "Water and Related Statistics", Central Water Commission, MOWR, July, 1998. (Irr - Irrigated; U.I. - Unirrigated.)

The national level average yields in the year 1991-92 for all foodgrains under rainfed and irrigated conditions were 1.0 and 2.33 tonne/ha respectively. It may be noted that average national total cereal yield in some countries has already exceeded 6 tonne/ha. Wheat yield up to 6,000 kg/ha on experimental farm has been achieved in this country also. In view of national and international experience, the Commission is of the view that good probability exists for achieving foodcrop yields as given in Table 3.22.

Table - 3.22

Future Foodcrop Yield Projections

(in tonnes per ha)

Year	2010	2025	2050
Rainfed foodcrop yields	1.1	1.25	1.5
Irrigated foodcrop yields	3.0	3.4	4.0

Source: See text.

Depth and Efficiency of Irrigation : The Irrigation Commission (1972) while estimating water requirement for irrigation assumed an average value of delta(or irrigation depth) as 0.76 m at national level for surface and ground water combined. Subsequently, the National Commission on Agriculture (1976) assumed that on an average 0.65 ham of ground water is required to irrigate a cropped hectare, and 0.9 ham if the source is surface water, as conveyance losses are higher in the latter.

The Net Irrigation Requirement (NIR) varies with the crop, climatic factors, effective rainfall during the crop growing period etc. There are a number of theoretical approaches which also take into account climatological factors. The Gross Irrigation Requirement (GIR) or "Delta" i.e. depth of irrigation at canal head is a function of Net Irrigation Requirement (NIR) and efficiency of conveyance of water through irrigation channels and application of water in the field. It may be defined as:

$$\begin{aligned} \text{GIR} &= \text{NIR / (Conveyance Efficiency x Application Efficiency)} \\ &= \text{NIR / Overall Irrigation Efficiency} \end{aligned}$$

Conveyance and application losses, that is field losses contributing to overall irrigation efficiency from source to field application, are expected to vary widely with the type of strata through which canal system passes, material used and quality of work in the canal lining, preparation of the field, type of soil, stream size and method of irrigation. Although no national level assesssments of overall irrigation efficiencies from surface and ground water are available, the Commission is of the view that 35 - 40 percent efficiency in surface water and 65 - 70 percent efficiency in ground water will be a fair approximation. With the increasing economic value and pressure on water supplies, improvement in overall irrigation would most likely take place in course of time. The Commission assumes that it should be possible to achieve the following (Table 3.23) levels of irrigation efficiency over time:

Table - 3.23

Projected Overall Irrigation Efficiencies

	Year 2010	Year 2025	Year 2050
Surface Water(percent)	40	50	60
Ground Water(percent)	70	72	75

NIRs for each block/district in the country have been estimated for prevailing cropping pattern using climatological approach by the concernred Agriculture Departments/Agriculture Universities and are reported in "Ground Water Resources of India" published by the Central Ground Water Board in 1995. The national weighted average value of NIR is estimated as 0.36 metre. The national weighted average values of GIR based on estimates of efficiency indicated in Table 3.23 would be as shown in Table 3.24.

Table - 3.24

Projected National Average Values of GIR (or "Delta")

(in metre)

Source of Water	Estimated byCGWB	Assumed Depth of Irrigation or "Delta"		
		Year 2010	Year 2025	Year 2050
NIR	0.36			
Ground Water :Assumed GIR		0.52	0.51	0.49
Surface Water :Assumed GIR		0.91	0.73	0.61

Source: See text.

Water Requirement for Irrigation: For meeting domestic demand for foodgrain, the water needed for irrigation for various years, based on assumptions made above, has been estimated, and is shown in Table 3.25.

Table - 3.25

Water Requirement For Irrigation

S. No.	Particulars	Unit	Year 2010		Year 2025		Year 2050	
			Low Demand	High Demand	Low Demand	High Demand	Low Demand	High Demand
1	Foodgrain Demand	million tonnes	245	247	308	320	420	494
2	Net Cultivable Area	million hectares	143	143	144	144	145	145
3	Cropping Intensity	%	135	135	140	142	150	160
4	% of irrigated to gross cropped area	%	40	41	45	48	52	63
5	Total Cropped Area	million hectares	193	193	202	204	218	232
6	Total Irrigated Cropped Area	million hectares	77	79	91	98	113	146
7	Total unirrigated Cropped Area	million hectares	116	114	111	106	105	86
8	Foodcrop area as % of irrigated area	%	70	70	70	70	70	70
9	Foodcrop area as % of unirrigated area	%	66	66	66	66	66	66
10	Foodcrop Area - Irrigated	million hectares	54.1	55.4	63.5	68.7	79.2	102.3
11	Foodcrop Area - unirrigated	million hectares	76.4	75.2	73.2	70.2	69.3	56.7
12	Average Yield - irrigated foodcrop	tonne/hectare	3	3	3.4	3.4	4	4
13	Average Yield - unirrigated foodcrop	tonne/hectare	1.1	1.1	1.25	1.25	1.5	1.5
14	Foodgrain Prod. from irrigated area	million tonnes	162	166	216	234	317	409
15	Foodgrain Prod. from unirrigated area	million tonnes	84	83	91	88	105	85
16	Total surrogate food production	million tonnes	246	249	307	322	422	494
17	Assumed % of potential from surface water to total irrigation potential	%	47	47	49	51	54.3	54.3
18	Irrigated area from surface water	million hectares	36.3	37.2	44.5	50.1	61.4	75.9
19	Irrigated area from ground water	million hectares	40.9	41.9	46.3	48.1	51.7	70.3
20	Assumed "Delta" for surface water	metre	0.91	0.91	0.73	0.73	0.61	0.61
21	Assumed "Delta" for ground water	metre	0.52	0.52	0.51	0.51	0.49	0.49
22	Surface water required for irrigation	km^3	330	339	325	366	375	463
23	Ground water required for irrigation	km^3	213	218	236	245	253	344
24	Total water required for irrigation	km^3	**543**	**557**	**561**	**611**	**628**	**807**

Source: See text.

We have estimated that by the year 2050, the water requirement for irrigation will be around 628 km^3 for low demand and 807 km^3 for high demand.

3.9 Water Requirement for Domestic Use

Suggested Norms: Various standards have been suggested for estimating water requirement for human use. Gleick(1997) has estimated 50 litres per capita per day (lpcd) as the basic human need. The World Health Organization (WHO) has suggested a target of 200 lpcd water supply in urban areas. A variety of factors affect water use in rural and urban areas. These include population size of a habitat, economic status, commercial and manufacturing activities. A host of other factors like climate, quality, technology, costs and conservation needs influence these requirements. Desirable and feasible norms can be established by reviewing past performance and modifying these on the basis of equity and sustainability.

Water supply norms of urban population listed by the Zakaria Committee (1963) varied between 67.5 lpcd and 270 lpcd. The Manual On Water Supply and Treatment (1976) by the Central Public Health and Environmental Engineering Organisation (CPHEEO) prescribed norms varying between 70 and 200 lpcd for urban areas. The National Commission on Urbanization (NCU) in its report (1988) argued for more realistic targets. The Eighth Five Year Plan (1992-97) adopted the following norms for water supply :

1. 125 lpcd for urban areas where piped water supply and underground sewerage system are available.

2. 70 lpcd for urban areas provided with piped water supply but without underground sewerage.

3. 40 lpcd for towns with spot-sources/stand posts with one standpost for 200 families with a maximum walking distance of 100 metres.

The rural water supply norms recommended by CPHEEO and the National Technology Mission ranged between 40 and 70 lpcd. Since fresh water sources are very unevenly distributed , it is not surprising that per capita water supply also varies widely ranging from 50 lpcd to 800 lpcd.

The existing national average of water supply, at the point of supply for Class I cities and class II cities are 182 and 103 lpcd respectively (CPCB, 1990). While suggesting the norms for water supply, the Commission has kept these standards in view. We suggest the final goal of providing 220 lpcd for the urban areas and 150 lpcd for the rural areas. These goals would be achieved in a phased manner as shown in Table 3.26.

Table - 3.26

Norms for Domestic Water Supply at Different Points of Time

(in lpcd)

Population Type	Year 2010	Year 2025	Year 2050
Class I Cities	220	220	220
Other than Class I Cities	150	165	220
Rural	55	70	150

Source: See text.

Assessment of Domestic Water Requirement: Domestic water requirement has been estimated by the Commission under the following two scenarios:

Scenario	**Population and rate of urbanisation**
High Water Requirement	Population as per Visaria & Visaria and high rate of urbanisation
Low Water Requirement	Population as per UN low variant and low rate of urbanisation

Based on population projections in Table 3.13 and the norms suggested in Table 3.26, the national water requirement for drinking and municipal uses at different point of time is estimated as follows:

Table - 3.27

National Water Requirements for Domestic & Municipal Use

(Quantity in km^3)

Scenario	Year 2010	Year 2025	Year 2050
Low Demand -Total	**42**	**55**	**90**
Surface Water	23	30	48
Ground Water	19	25	42
High Demand - Total	**43**	**62**	**111**
Surface Water	24	36	65
Ground Water	19	26	46

Source: See text.

Thus, the total water requirement for domestic use for rural and urban areas is estimated as 90 km^3 and 111 km^3 in two scenarios. The water requirements of 34 million-plus cities for the years 2000, 2010 and 2015 would be 8.7 km^3, 11.6 km^3 and 13.2 km^3 respectively, which is included in the total requirement. It is further assumed that 70 percent of urban and 30 percent of rural water requirement would be met from surface water sources and balance from ground water sources.

Bovine Water Requirement: Reviewing the past growth in bovine population, the Commission assumed future bovine population growth at the rate of 0.5 per cent per year, while keeping in view the carrying capacity of the system and likely stress on natural resources. Further, water requirement norms between 18 to 30 lpcd per animal have been assumed. Using 1992 livestock census figure and postulating a growth of bovine population at 0.5 percent, the total figures of bovine population for the years 2010, 2025 and 2050 have been arrived at. Applying the norms of water requirement per animal as given above, we have estimated water requirement for bovine population as 4.8 km^3, 5.2 km^3 and 5.9 km^3 for the years 2010, 2025 and 2050 respectively, which is included in the total water requirement.

3.10 Water Requirement for Industries

It is extremely difficult to estimate future water requirements of industries. There is a serious dearth of information on the present use of water by industries. This is further compounded by the uncertainity about the future growth and composition of manufacturing activities. Several assumptions have to be made to arrive at the figures of water requirement.

The share in Gross Domestic Production (GDP) of Industrial sector was 21.5 and 23.3 per cent respectively in the years 1991-92 and 1996-97.The industrial sector has recorded the compound growth rate of 4.6 percent from 1970-71 to 1979 –80 and 6.6 percent from 1980-81 to 1989-90 at constant prices. Its future growth is likely to be accelerated.

For understanding the industrial scenario of the country, Planning Commission has divided the industries into 17 categories. The same categorisation has been considered by us for estimating water requirement for this sector.

The projected production figures for 2002 in the Ninth Five Year Plan were used as base figure. The overall rate of growth for all sectors of industries was assumed as 9 percent. The rates for the growth of each sector, as observed from the draft Ninth Plan document, were adopted for working out the future production capacity of the various industrial sub-sectors. For sensitivity analysis, production capacities for low and high scenarios have been considered as 95 percent and 105 percent of the original estimates. The analysis did not yield any substantial difference to the original estimates.

The per unit water consumption figures are based on information available with the Central Pollution Control Board (CPCB) and the information obtained from different associations of industries. In some cases, a reputed industrial unit was contacted for obtaining the per unit water requirement of that particular sector. Sliding scale of water requirement has been adopted in view of the likely emergence of water saving technologies.

The water requirements for industrial development estimated by the Commission are 37 km^3, 67 km^3 and 81- 103 km^3 for the years 2010, 2025 and 2050 respectively. The requirement of 103 km^3 in the year 2050 corresponds to the present rate of use of water, whereas the requirement of 81 km^3 in the year 2050 assumes significant breakthrough in adoption of water saving technologies for industrial production. We have used the latter figure in our estimates of total water requirement for the year 2050. 70 percent of water requirement is expected to be met from surface water sources and remaining 30 percent from ground water sources.

3.11 Water Requirement for Power Development

Power Scenario: Another important developing sector of economy using substantial quantity of water is Power Sector. The installed generating capacity, which was only 1,362 MW in 1947, has increased nearly seventy fold, to 92,281 MW, by March, 1999. Coal, oil, gas and hydroelectric potential constitute the conventional sources for electricity generation in the country. Of these, coal-based thermal power plants and, in some regions, hydro-power, have been the mainstay of electricity generation. Oil, natural gas and nuclear power account for a smaller portion of total power supply (from the installed capacity). The percentage of installed thermal, hydel and nuclear power station capacities are around 73, 24 and 3 respectively. Hydro-electricity has still vast untapped potential.

According to the surveys carried out during the years 1978 to 1987 by the Central Electricity Authority (CEA), 845 economically feasible schemes have been identified in the various river basins of the country with a total hydro electric potential of 84,044 MW at 60 percent load factor.

On account of economy in power generation from coal on the one hand and high initial investment and long gestation period in construction of hydel schemes on the other, there is little doubt that coal-based generation will continue to be the mainstay of India's power sector for the foreseeable future. Yet hydel power would play a dominant role for peak energy requirement on account of ease in *On* and *Off* (The economic value of peak energy is much higher than base energy).

Projected Installed Capacity: The Fourth National Power Plan (Year 1997) assumed a compound growth rate of 7 percent in the installed generating capacity for the country during the period 1997 - 2012. The Commission has made estimates of future installed capacity, assuming compound growth rate of 7 percent per year up to the year 2025, and 6 percent during the period 2025 to 2050. The source-mix assumption has been made keeping in view the known potential, capital cost, gestation period, economic and environmental implications relating to hydropower, nuclear energy and other renewable sources of energy. For sensitivity analysis, production capacities for low and high scenarios have been taken as 95 per cent and 105 per cent of projected capacity.

Standards of Water Use: Normally, water is drawn for thermal and nuclear power stations from the rivers, canals and ponds and the cooling water system could either be a direct cooling system for condenser i.e. without cooling towers where a substantial quantity of water is returned back to the source, or an indirect cooling system with cooling towers which are a part of a closed circuit system and in which case all the make-up water drawn from the source ultimately becomes consumptive. The nuclear power stations handle much larger quantities of cooling water for condensers and other auxiliaries as also for the heat transport system between the reactor and the steam generator. The boiler water needs are very low compared to cooling needs.

In a communication to the Commission, the Central Electricity Authority has suggested water requirements for a typical coal-fired power station using cooling towers as under :

a.	Consumptive	4.48 m^3/hour/ MW or 3.92 Mm^3/year/100 MW
b.	Non-consumptive	1.32 m^3/hour/ MW or 1.15 Mm^3/year/100 MW

Water use norms for different types of power stations were collected by the Commission from Central Electricity Authority, from a few(Rajasthan,Maharashtra) State Electricity Boards, Bhakra Beas Management Board, and were compared with actual water use by some major power stations of National Thermal Power Corporation and the plants of Punjab State Electricity Board. It was observed that there is a gradual shift towards economy in water use and zero water discharge from thermal power plants. In view of this, a sliding scale of consumptive water use has been considered for estimation of water requirement in the case of coal based thermal power stations. Non consumptive water use has been ignored in view of the fact that there is hardly any quality deterioration of water released from thermal power stations.

Hydropower stations in general do not have any consumptive use except for evaporation from reservoirs. About unused discharges through turbines located near sea coast, the Commission is of the view that such unused releases should get minimised as the demand for water would increase in future. However, lump sum provision has been made to account for such releases keeping in view the existing and likely future releases. Norms for water requirement for nuclear, wind/solar and gas based plants have been taken keeping in view the existing scales of use and emerging technologies.

Water Requirement: Water requirement for energy/power sector has been estimated by us for low and high demand scenarios as 18 km^3 and 19 km^3, 31 km^3 and 33 km^3 , and 63 km^3 and 70 km^3 respectively for the years 2010, 2025 and 2050. Eighty percent of water requirement is expected to be met from surface water sources and balance twenty percent from ground water sources.

The details of projected installed capacity, norms of consumptive water use and water requirements are given in Table 3.28.

Table - 3.28

Estimate of Water Requirement for Power Sector

S.No.	Category	2010		2025		2050	
		Low Scenario	High Scenario	Low Scenario	High Scenario	Low Scenario	High Scenario
	Installed Capacities - Mw						
1	Thermal	118,004	130,426	392,664	433,977	2,008,034	2,219,406
2	Hydropower	63,512	70,198	79,800	88,200	79,800	88,200
3	Nuclear	10,213	11,288	39,777	43,964	129,248	142,853
4	Solar/Wind	2,138	2,363	6,498	7,182	21,100	23,321
5	Gas based	3,377	3,733	12,315	13,608	39,995	44,205
	Total	197,244	218,008	531,054	586,931	2,278,177	2,517,985
	Norm for Water Requirement(0.001km^3/Year/100Mw)						
1	Thermal	2.38	2.63	2.00	2.21	1.43	1.58
2	Hydropower	LS	LS	LS	LS	LS	LS
3	Nuclear	2.85	3.15	2.85	3.15	2.85	3.15
4	Solar/Wind	0.17	0.18	0.17	0.18	0.17	0.18
5	Gas based	0.45	0.49	0.45	0.49	0.45	0.49
	Total Water Requirement (km^3/Year)						
1	Thermal	2.81	3.43	7.85	9.59	28.71	35.07
2	Hydropower	15.00	15.00	22.00	22.00	30.00	30.00
3	Nuclear	0.29	0.36	1.13	1.38	3.68	4.50
4	Solar/Wind	0.00	0.00	0.01	0.01	0.04	0.04
5	Gas based	0.02	0.02	0.06	0.07	0.18	0.22
	Total	**18.1**	**18.8**	**31.1**	**33.1**	**62.6**	**69.8**

Source: see text.

According to CEA, the water requirements for the thermal plants likely to be commissioned by the end of 11th Five Year Plan i.e. 2012 AD would be 5 km^3. Considering nine percent annual growth of demand of energy, the water requirements at the end of 2025 AD and at the end of 2050 AD for thermal power plants shall be of order of 15 and 30 km^3 respectively.

3.12 Water Requirement for Inland Navigation Development

Navigation Scenario: Navigable waterways in India, comprising of river systems, canals, backwaters, creeks and tidal inlet, extend to about 14,500 Kms. Most waterways, however, suffer from navigational inadequacies such as shallow waters, narrow width, siltation and bank erosion. Moreover, vertical and horizontal clearances at overhead structures are not adequate for navigation throughout the year. Consequently, at present about 5,200 kms of major rivers and 485 kms of canals are considered suitable for mechanised crafts.

The total cargo moved by inland waterways transport is about 16 million tonnes equivalent to just one billion tonne kms per annum, compared to total inland cargo of about 900 billion tonne kms per annum.

The Bhagwati Committee identified 56 navigable waterways in 12 states of the country. Following ten waterways were identified as National Waterways by the Committee:

- Ganga-Bhagirathi-Hoogly River System;
- The Brahmaputra River;
- The West Coast Canal;
- The Godavari River;
- The Sunderbans;
- The Mandovi, Zuari and Cumberjua Canal in Goa;
- The Krishna River;
- The Mahanadi River;
- The Narmada River; and
- The Tapi River.

Of the above,the first three waterways have already been declared as National Waterways.

Projection of Future Cargo : The Inland Waterways Authority has estimated that with expected 10 percent industrial and six percent GDP growth, the inland surface cargo transport would be about 1200 billion tonne kms per annum by the year 2000. No estimates are available beyond this year .

Standards : The requirement of water for the purpose of navigation is guided by the two-way movement of vessels of appropriate capacity and dimensions using the waterway. The National Transport Policy Committee (1980) has recommended about 45 m width and minimum 1.5 m depth of the channel for declaration as National Waterway.

The requirement of flow of water for navigation purpose i.e. design depth and width of navigation channel is dependent on various complex hydromorphological parameters and will vary for different waterways and even in different sections of the waterways. No minimum discharge requirement for any inland waterway, therefore, can be prescribed. Technically, it is feasible to make the rivers navigable through proper structural arrangements even without releasing appreciable volume of water; the ruling criterion would be economic feasibility.

Water Requirement : The requirement of flow in water channel needs are mostly expected to be met by seasonal flows in various river systems or canals. However, in the event of damming of entire river flow, some water would be required to be released from upstream reservoirs for keeping the waterways navigable particularly during lean flow season. It is also likely, in certain cases, that the minimum flows released from essential environmental consideration may exceed the flow need for inland navigation.

In view of the aforesaid considerations and taking into account the actual releases downstream of Farakka Barrage as an example, the Commission has projected 7 km^3, 10 km^3 and 15 km^3 water for the years 2010, 2025 and 2050 respectively for navigational purposes.

3.12 Water Requirement For Flood Moderation

In many places, construction of dams has caused flood moderation in the down stream areas. Large areas which were regularly flooded prior to construction of dams, have now become less prone to flooding. Subsequently, on account of un-regulated development, major obstructions in the waterways were created and settlement also took place on low banks. Due to these developments, in the event of high floods, regulation of flows from reservoirs located up-stream, though not planned originally, has become essential for protecting the lives and properties. Thus, it became necessary to earmark some storage capacity for moderating the releases. The earmarked capacities are kept empty during early part of monsoon season and later allowed to be used for storing the river flows. Any part of earmarked storage lying empty after monsoon season is over, is termed, by many, as equivalent quantity of water utilised for flood control.

The Commission feels that situations in which storage capacities are reserved for flood control purpose are casual in nature and would require either creation of additional storage or other suitable flood control measures and not additional water and, therefore, has decided to provide nil water requirement for flood moderation.

3.13 Water Requirement for Environment and Ecology

Importance and Need : In the earlier period with less of population and consequently less of related activities, nature could cope with whatever damage was inflicted on the resources, quickly restoring the balance. But in recent times, with the growth of human number and multiplication of human wants and consequent activities, the restorative capacity of nature and the environment is being continuously depreciated, affecting the quality of life on the planet Earth. Ecology is now concerned not only with living elements, but also with their interrelationships with society and culture. Prevention of environmental degradation and degradation of natural resource base is essential for sustainable development.

The negative environmental consequences are caused due to deforestation, soil erosion,unplanned industrialisation, indiscriminate use of fertilisers and pesticides in agriculture, droughts, floods, water logging, water pollution, heavy population growth, large scale poverty etc. Global climatic change and atmospheric pollution could also have an impact on fresh water resources and their availability. Protection, enhancement and restoration of water quality and abatement of water pollution are necessary for providing not only safe drinking water and maintaining and improving human health but are also important for sustaining land quality, agriculture and industrial production, in fact, socio-economic growth as such.

Increasing paucity of water and aggravated pollution of water resources are the major ecological concerns. Dense forest cover which was estimated at 40 percent of land area in the last century is now reduced to less than 14 percent. Most of the rivers now carry polluted water during a major part of the year.

Two types of water requirement have been considered for the purpose of environmental protection viz. (a) for afforestation and tree planting and (b) for abatement of water pollution and maintaining water quality safe for drinking and other uses in the streams/rivers and other water bodies.

Water Requirement for Afforestation: The country's forests have been under heavy pressure for many decades. The loss of dense, closed forests has had serious consequences for the country's biodiversity. The total recorded forest area of the country is 76.5 Mha or about 23 percent of the total geographical area. However, the tree cover area is only about 63.34 Mha or 19.25 percent of total geographical area, out of which only 36.72 Mha or 60 per cent has good forest cover having crown density of more than 40 per cent. Over a longer period, India has suffered massive forest losses. Between 1995 to 1997 there has been a decrease in forest cover of 548,200 ha in the country (Ministry of Environment and Forests, 1997).

India's forests can sustainably provide about 0.041 km^3 of fuelwood per year, yet current demand is thought to be about 0.240 km^3 annually. In addition, industrial wood requirements are over twice as high as silvicultural productivity. Of India's 400 million heads of cattle, about 90 million graze in forest, whereas the carrying capacity is estimated at 31 million. The great challenge that faces the country's forest managers is restoring and increasing India's forest cover which eventually may require large quantity of water. The National Commission, however, feels that requirement of water for initial tree fixing and subsequent maintenance would be met mostly from precipitation and soil moisture. Therefore, no separate water requirement has been provided for this purpose.

Requirement for Abatement of Pollution & Managing Quality of Waters : Rivers and other water bodies are being polluted at both point and non-point sources. Pollution at point sources is due to discharges of urban sewage and industrial effluents which contain organic pollutants, chemicals, and heavy metals. The non-point sources of pollution are run-offs from irrigated land, urban solid waste dumps, open defecation areas etc. While the major contributor of water pollution is urban sewage, industrial waste though small in volume, contributes significantly in terms of the total pollutant load. Instances of high pollution from irrigated lands using heavy doses of fertilizers and insecticides have been observed in certain parts of the country .

Water Quality Status & Standards for Rivers : Water quality of rivers is classified into five categories based on the end use of water :

- *Class A* - Drinking water source without conventional treatment but after disinfection.
- *Class B* - Outdoor bathing.
- *Class C*- Drinking Water source with conventional treatment followed by disinfection.
- *Class D*- Propagation of wild/aquatic-life.
- *Class E* - Irrigation, industrial cooling, and waste disposal.

The quality of water is being monitored by 480 stations in the country. Almost 80 percent of the total river stretches fall under Class C or lower category , signifying the need to apply conventional and/or tertiary treatment methods to make the water fit for household and other uses(TERI, 1998).

To give a few examples, biochemical oxygen demand (BOD) ranged between 2-15.5 mg/litre against tolerable limit of 3 mg/litre in the Ganges between Rishikesh to Patna in the year 1986 . The water quality in river Yamuna downstream of Okhla has greatly deteriorated and rendered the same unfit for use. Delhi metropolitan area currently produces about 2 billion litres sewage most of which outfalls into Yamuna without treatment. The average BOD of sewage is 300 mg/litre. Even if the entire sewage from Delhi is treated to required effluent standard of 30 mg/litre before outfall, *about 3.0* km^3 fresh water release is essential in the river to restore the quality of water to a safe limit of 3 mg/litre. These examples demonstrate the magnitude of the problem. Similar conditions prevail in practically all major rivers.

Estimation of fresh quantity of water needed for managing ecological standards for all water bodies including lakes and rivers on sustainable basis is not possible at present. Even the quantity of water required for dilution and treatment of sewage in all the rivers in the country, is just not available. Alternative methods will have to be evolved and operationalised.

In view of aforesaid considerations, we decided to make token provisions of 5 km^3 , 10 km^3 and 20 km^3 of water for this purpose for the years 2010, 2025 and 2050 respectively. It is suggested that periodic reassessment of this requirement should be made taking into account all relevant data on sources and extent of pollution, technologies, and institutional arrangements.

3.14 Water Requirement to Compensate Evaporation Losses From Reservoirs

Evaporation from reservoir surface is well known phenomenon. It renders equivalent quantity of water non-available for use. To avoid chances of multiple accounting, the Commission has decided to exclude component of reservoir evaporation from water requirement of different sectors and provide the same separately.

Norms: Quantitatively loss of water due to evaporation from reservoir depends to a large extent upon reservoir geometry, actual water surface area during the period of storage and the rate of pan-evaporation. On account of complexities in estimation of aggregate evaporation from reservoirs, rate of evaporation from reservoir is, generally, quantified or defined in terms of percent of reservoir capacity.

The Technical Advisory Committee of National Water Development Agency has prescribed a norm of evaporation losses from reservoirs as 20 per cent of withdrawals. This approach is difficult to follow for calculating national level estimate of evaporation losses from reservoirs as the data of withdrawals from all reservoirs are not available.

The Commission has decided to adopt the alternative method of estimation of reservoir evaporation based on live storage capacity. Using evaporation data of 29 major and medium reservoirs(provided by NWDA), a national average value has been estimated as 15 percent of live storage capacity. Evaporation losses from minor projects have been taken as 25 percent of their live capacities.

Water Losses: The evaporation losses from reservoirs have been estimated to be 42 km^3, 50 km^3 and 76 km^3 by the years 2010, 2025 and 2050 respectively. Details are shown in Table 3.29.

Table - 3.29

Water Losses Due to Evaporation

(Quantity in km^3)

Particulars	1997	2010	2025	2050
Live Capacity-Major storage	173.728	211.439	249.15	381.5
Live Capacity-Minor storage	34.7	42.3	49.8	76.3
Evaporation from major Res. @ 15 % of live capacity	**26.1**	**31.7**	**37.4**	**57.2**
Evaporation from minor Res. @ 25 % of live capacity	**8.7**	**10.6**	**12.5**	**19.1**
Total Evaporation loss	**35**	**42**	**50**	**76**

Source: See text.

3.15 Total Water Requirement

The estimated total water requirement for various sectors of use is summarised in Table 3.30.

Table - 3.30

Water Requirement for Different Uses

(Quantity in Km^3)

S.No.	Uses	Year	Year 2010			Year 2025			Year 2050		
		1997-98	Low	High	%	Low	High	%	Low	High	%
	Surface Water:										
1	Irrigation	318	330	339	48	325	366	43	375	463	39
2	Domestic	17	23	24	3	30	36	5	48	65	6
3	Industries	21	26	26	4	47	47	6	57	57	5
4	Power	7	14	15	2	25	26	3	50	56	5
5	Inland Navigation		7	7	1	10	10	1	15	15	1
6	Flood Control		-	-	0	-	-	0	-	-	0
7	Environment (1)Afforestation		-	-	0	-	-	0	-	-	0
8	Environment (2)Ecology		5	5	1	10	10	1	20	20	2
9	Evaporation Losses	36	42	42	6	50	50	6	76	76	6
10	**Total**	**399**	**447**	**458**	65	**497**	**545**	**65**	**641**	**752**	64
	Ground Water:										
1	Irrigation	206	213	218	31	236	245	29	253	344	29
2	Domestic & Municipal	13	19	19	2	25	26	3	42	46	4
3	Industries	9	11	11	1	20	20	2	24	24	2
4	Power	2	4	4	1	6	7	1	13	14	1
	Total	**230**	**247**	**252**	35	**287**	**298**	**35**	**332**	**428**	36
	Grand Total	**629**	**694**	**710**	100	**784**	**843**	**100**	**973**	**1180**	100
	Total Water Use:										
1	Irrigation	524	543	557	78	561	611	72	628	807	68
2	Domestic	30	42	43	6	55	62	7	90	111	9
3	Industries	30	37	37	5	67	67	8	81	81	7
4	Power	9	18	19	3	31	33	4	63	70	6
5	Inland Navigation	0	7	7	1	10	10	1	15	15	1
6	Flood Control	0	0	0	0	0	0	0	0	0	0
7	Environment (1)Afforestation	0	0	0	0	0	0	0	0	0	0
8	Environment (2)Ecology	0	5	5	1	10	10	1	20	20	2
9	Evaporation Losses	36	42	42	6	50	50	6	76	76	7
	Total	**629**	**694**	**710**	**100**	**784**	**843**	**100**	**973**	**1180**	**100**

Source: See text and Tables - 3.25, 3.27, 3.28 and 3.29.

According to our assessment, total water requirement of the country would be 694 to 710, 784 to 843 and 973 to 1,180 km^3 by the years 2010, 2025 and 2050 respectively depending on the low demand and high demand scenarios. Irrigation would continue to have highest water requirement, between 628-807 km^3 (or about 68 percent of total water requirement), followed by domestic water use, including drinking and bovine needs, at about 90-111 km^3 (or about 10 percent of total water requirement), industries would require at 81 km^3 (or about 7 percent of total water requirement), evaporation would amount to 76 km^3 (or about 6 percent of total water requirement), and power generation would need between 63 to 70 km^3 (or about 6 percent of total water requirement), environmental needs, navigation needs, etc. will amount to 35 km^3 (or 3 percent of total water requirement), in the year 2050.

If the country desires to irrigate all cultivable land at 100 per cent intensity of irrigation by the year 2050, the water requirement for irrigation in the year 2050 would be 1451 km^3 and the total water requirement will be 1,824 km^3. This is a hypothetical scenario.

3.16 Basin and State Water Requirements

It was pointed out earlier that there are vast differences in availability of water from one basin to another. This is also true of availability of water in different states. As the basic unit of an integrating water plan would be a basin or a state, it is important to analyse the water balance between availability and requirement on a basin/state level. The Commission has estimated the water balance basin-wise and water requirements state-wise for years 2010,2025 and 2050 for low and high demand scenarios. It may be reiterated that the overarching objective of this exercise is achievement of food self sufficiency at the national level.

Basin and State Water Requirements for low and high demand scenarios have also been estimated on the following assumptions:

- The projected net sown area for each basin/state has been estimated in proportion to actual net sown area of the basin/state during 1992-93 keeping the national net sown area between 143 and 145 Mha.

- The projected basin/state population has been estimated in proportion to their respective population in 1991.

- Basin/state water requirements for industries and energy development have been estimated by averaging the water requirements computed on the basis of national averages of per capita and per ha of geographical area.

Besides, specific assumptions had to be made to estimate basin-wise and state-wise projection of water requirements. The basin-wise study assumed:

- Basinwise land use, irrigation and other data have been computed from available state-wise data in proportion to the area of the state falling in the basin.

- The projected average gross depth of irrigation for each basin has been estimated by averaging the value for each state falling in the basin.

- The projected foodgrain yield of each basin has been estimated by averaging the value of each state falling in the basin.

- Proportion of gross irrigated to gross cropped area and proportion of irrigation from surface and ground waters have been adjusted,while keeping the overall surface and ground water surplus/deficit in each basin nearly in equal proportion to utilisable water resources.

Similarly, State-wise Estimates were based on:

- Percentage of gross sown to net sown area, percentage of gross irrigated to gross cropped area and proportion of irrigation from surface and ground waters have been adjusted while keeping the overall gap between ultimate and projected irrigation potentials of each state from surface and ground water in nearly equal proportion.

It will be clear from above that the basin and state projections are based on heroic assumptions and should be treated as first approximations. It is, therefore, suggested that basinwise and statewise estimates should be revised periodically after validating the assumption and collection of basinwise land use and other data in consonance with national plan.

The figures of basin and statewise water requirement and availability are shown in Annexures - 3.2 and 3.3 respectively.

In the states or basins with less abundant water resources, the intensity of land use and employment opportunity in the agricultural sector will be constrained by the availability of water. Such states or regions will have to adopt a different pattern of economic development, though there is no reason why they should not achieve the same or even higher level of income generation for their people.

3.17 Water Available from Return Flows

As stated earlier, water used for a particular activity includes both consumptive and non-consumptive elements. While water for consumptive use is entirely lost in the process, the non-consumptive part is returned back to the hydrologic system in the form of surface discharges and infiltration in the ground water sources. Part of this return flow to the hydrologic system is recoverable and may be recycled for suitable uses. We have considered utilisable return flows from irrigation, domestic and municipal and industrial uses. While return flow from irrigation and domestic uses would contribute to utilisable ground and surface water resource, the return flow from industry is assumed to contribute to utilisable surface water only. The quantities of return flow are in addition to the utilisable water resources considered in Section - I.

We have also noted that making multiple-use of the same water, though important for augmenting the resource, also carries the risk of pollution of water resources.

Return Flow from Irrigation: It is expected that the difference between water supplied for irrigation and consumptive use for irrigation, that is the non-consumptive use would comprise of the following:

- Return flow to ground and surface water source - 60 percent of imbalance,*
- Flow to swampy areas - 30 percent of imbalance, and
- Flow to ocean - 10 percent of imbalance.

(* Imbalance means the difference between gross and net irrigation requirement.)

Return flow for six peninsular basins, namely Godavari, Krishna, Cauvery, Mahanadi and Pennar having paddy as major crop has been calculated by the following relationship :

Return Flow $= 0.60 \times [\text{GIR} - \{ET_0 - \text{Effective Rainfall}\}]$

Where GIR = Gross Irrigation Requirement

and ET_0 = Potential Evapotranspiration.

For other basins and all states, the return flow from surface and ground water irrigation has been estimated depending on overall irrigation efficiencies. Following Table gives percent of return flow to the water delivered for irrigation from source(i.e.GIR).

Table - 3.31

Return Flow As Percentage of Irrigation Supplies

(in percent)

Source of Water	Surface Water			Ground Water		
Year	2010	2025	2050	2010	2025	2050
Overall Irrigation Efficiency(%)	40	50	60	70	72	75
Return-flow as % of GIR	36	30	24	18	17	15

Ninety percent of return flow from irrigation is expected to contribute to ground water source and balance 10 percent to surface water source.

Return Flow from Domestic & Municipal Use: The Commission has estimated return flow from urban and rural uses at the rate of 50 percent of supplies. It is expected that 85 percent of the return flow would go to surface water source and balance 15 percent to ground water source.

Return Flow from Industrial Use: The return flow has been estimated at overall average of 50 percent of the supplies, all of which is expected to contribute to surface water source.

Total Estimated Return Flow: The quantities of utilisable return flow from various sectors has been estimated to vary between 213 km^3 to 259 km^3 in the year 2050 as shown in Table 3.32:

Table - 3.32

Return Water - Available For Reuse

(Quantity in km^3)

Source	Year 2010		Year 2025		Year 2050	
	Low	High	Low	High	Low	High
Ground Water						
Irrigation	141	145	123	136	115	147
Domestic Water Supply	3	3	4	5	7	8
Total of ground water	144	148	127	141	122	155
Surface Water						
Irrigation	16	16	14	15	13	17
Domestic Water Supply	18	18	23	26	38	47
Industrial Effluent	18	18	33	33	40	40
Total of Surface Water	52	52	70	74	91	104
Grand Total	**196**	**200**	**197**	**215**	**213**	**259**
Less existing Return Flow	90	90	90	90	90	90
Additional Return Flow	106	110	107	125	123	169

Source: See text.

3.18 General Observations

In this chapter, we have presented an overview of the likely situation in the availability and requirements of water upto year 2050. These estimates should be treated basically as approximations. These do not and cannot take into account impacts of unforseen technologies. It would be desirable to review these estimates regularly, say, at the interval of 5 –10 years.

Summary of water availability and requirements at three levels viz. National, basin and state levels is provided in Table 3.33. The three exercises give approximately the same result. It will be seen that the country's total water requirement barely matches the estimated utilisable water resources.

The lesson is clear. It is of paramount importance that we should aim at reducing water requirement to the low demand scenario. Taking into account the water availability and the requirements till the year 2050, the Commission concludes that there is no need to take an alarmist view. However, three major considerations have to be kept in the forefront while formulating an integrated water policy and plan. First, the balance between the requirement and availability can be struck only if utmost efficiency is introduced in water use. Second, average availability at the national level does not imply that all basins are capable of meeting their full requirement from internal resources . Third, the issue of equity in the access to water, between regions and between sections of population, assumes greater importance in what is foreseen as a fragile balance between the aggregate availability and aggregate requirement of water. In the following chapters, we address these and related problems of integrated water use planning in the context of supply and requirement of water estimated by the Commission.

Table - 3.33
Utilisable Water, Requirement and Return Flow
(Quantity in km^3)

S.No.	Particulars	Year 1997-98	Year 2010 Low Demand	Year 2010 High Demand	Year 2025 Low Demand	Year 2025 High Demand	Year 2050 Low Demand	Year 2050 High Demand
1	**Utilisable Water**							
	a. Utilisable Surface	690	690	690	690	690	690	690
	b.Utilisable Ground Water	396	396	396	396	396	396	396
	c.Existing Augment-ation From Canal Irrigation	90	90	90	90	90	90	90
	Total of (a+b)	**996**	**996**	**996**	**996**	**996**	**996**	**996**
2	**Total Water Requir-ement - based on**							
	a.National Average :							
	Surface water	399	447	458	497	545	641	752
	Ground water	230	247	252	287	298	332	428
	Total	629	694	710	784	843	973	1180
	b. Basin Study:							
	Surface water		Not Assessed				642	751
	Ground water		Not Assessed				331	429
	Total		Not Assessed				973	1180
	c. State Study:							
	Surface water		448	457	496	546	641	751
	Ground water		246	251	287	297	332	427
	Total		694	708	783	843	973	1178
3	**Return Flow based on:**							
	a.National Average :							
	Surface Water	43	52	52	70	74	91	104
	Ground Water	143	144	148	127	141	122	155
	Total	186	196	200	197	215	213	259
	b. Basin Study:							
	Surface water		Not Assessed				93	107
	Ground water		Not Assessed				148	186
	Total		Not Assessed				241	293
	c. State Study:							
	Surface water		52	53	70	75	92	104
	Ground water		145	148	128	141	122	155
	Total		197	201	198	216	214	259
4	**Residual Utilisable Water (4 = 1 - 1(c) - 2 + 3) Balance based on:**							
	a.National Average :							
	Surface Water	334	295	284	263	219	140	42
	Ground Water	219	203	202	146	149	96	33
	Total	553	498	486	409	368	236	75
	b. Basin Study:							
	Surface water		Not Assessed				141	46
	Ground water		Not Assessed				123	63
	Total		Not Assessed				264	109
	c. State Study:							
	Surface water		294	286	264	219	141	43
	Ground water		205	203	147	150	96	34
	Total		**499**	**489**	**411**	**369**	**237**	**77**

Note : 1.The total utilisable water resources do not take into account likely reduction in utilisable surface water resources due to reservoir sedimentation which is estimated to be about 17 percent of the total live storage capacity by year 2050.

CHAPTER – 4

DEVELOPMENT AND MANAGEMENT ISSUES IRRIGATION, FLOOD CONTROL, HYDRO POWER AND NAVIGATION

I. Irrigation

With the partition of India in 1947, large parts of irrigated area went to Pakistan. The food production in India fell short of its requirements and the country had to import large quantities of foodgrains in the fifties and sixties. Very high priority was, therefore, given to stepping up of food production through irrigation. As a result of the thrust on irrigation development and agricultural research, hybrid varieties of wheat and rice thrived and the entire programme met with a spectacular success. During the last five decades, food production and gross irrigated area increased four fold. As stated in chapter 2, such a large and widespread programme of implementation of irrigation development and management has also created several problems concerning equity, environment, lack of drainage, lag in utilisation and efficiency. Various ameliorative measures including rehabilitation of existing schemes, regulation and control of use of water including legal enactments have been planned and are in the process of implementation. There was initially considerable lag in irrigation utilisation. Command Area Development Authorities were, therefore, created and micro channels were sought to be extended right down to the field, partly at government cost and partly through input by the farmers. A modernisation programme was taken up covering both old (pre-independence) and new (post independence) projects with the objective of reducing water loss and rendering the operation of the system efficient. However, the involvement and co-operation of the irrigators have been inadequate. There are also other issues such as inadequate drainage, inequitable distribution of water between the head reach and tail end areas, the distribution and control of inter-state river waters which have created water disputes amongst the basin states and regional inequalities. All such issues of development and management must be identified and appropriate measures taken to improve the efficiency of water use and ensure equity while meeting water requirements, without adversely affecting the environment. Water has now become precious and a scarce commodity and a limiting factor in regard to increase in agricultural production. The entire programme has, therefore, to be managed in such a way that optimal benefits of irrigation are available on a sustainable basis.

The performance and appraisal of past activities as well as improvements needed for the future are discussed in this chapter under various sub heads.

4.1 Irrigated Agriculture in Earlier Years

The older irrigation works prior to 19th century were mainly confined to construction of ponds to collect excess rainfall, to direct flood flows through inundation channels or canals and simple dugwells, where favourable ground water conditions existed. In the past, several kings took upon themselves the responsibility to create reliable water supply systems in their respective domains. Grand Anicut in the Cauvery river delta was one of the earliest canal systems built as far back as the 2nd Century A.D. Historical evidence points out that Ghiyasuddin Tughlaq (1220-25) was one of the first rulers who took interest in digging canals at the state's expense. Similarly, Firoz Tughlaq (1351-86), who was inspired by the Central Asian experience, built a number of canals. The Vijaynagar Empire expanded primarily because of large impetus provided to irrigation works in the 15th century in southern India. In the nineteenth century, British rule in India brought about a significant change in water resource development. Some large and extensive works like Upper Ganga Canal, the Upper Bari Doab Canal and the Krishna and Godavari Delta Systems were taken up, which were all river diversion schemes of fairly large size. In 1867, Government adopted the practice of accepting works which promised a minimum net return. Thereafter, a large number of projects were taken up such as the Sirhind Canal, the Lower Ganga Canal, the Agra Canal, the Mutha Canal, Periyar Dam, the Lower Swat Canal, the Lower Soliag Canal, the Lower Chenab and the Sidhnai Canals. Owing to frequent droughts and famines during the second half of the 19th century, irrigation development received special attention. Some of the protective works constructed during the period were the Betwa Canal, the Nira Left Bank Canal, the Gokak Canal, the Mahaswad Tank and the Rushikulya Canal. The total irrigated area towards the end of the 19th century, both by public and private works, was around 13.2 Mha of which 56 percent constituted the public works. Sourcewise, canals irrigated 45 percent, wells 35 percent, tanks 15 percent and other sources five percent of the area.

The First Irrigation Commission was appointed in 1901 to report on irrigation as a 'means of protection against famine in India'. Prior to setting up of this Commission, a few Famine Commissions had been set up and those Commissions had also recommended the development of irrigation works to contain the adverse impact of frequent famines. However, it was only after the appointment of the First Irrigation Commission that a number of ambitious construction programmes were taken up to fight famine. The Commission in its Report recommended financial yardsticks for taking up famine relief and protective works. It also made a thorough review of irrigation development in the provinces and recommended proposals for new schemes. The more important public works recommended by the Commission included Chankapur storage on river Girna, Maladevi storage on river Pravara, storage works on the rivers Ujjani and Ghataprabha, improvement of Kurnool-Cuddapah Canal, storage works on rivers Cauvery and Krishna, the Ken Canal, the diversion of Sarada waters into the Ganga above the Narora weir and location of suitable storage sites on the rivers Sabarmati, Mahi and Narmada.

It was also recommended that a number of small works could be conveniently taken up for famine relief for various provinces. The Commission attached considerable importance to the development of private irrigation works and recommended that grants-in-aid be provided for land improvement works including wells in the tracts affected by famine and reducing the rate of interest on loans to five percent.

Almost all the major recommendations made by the First Irrigation Commission were implemented by the Government, in full or with some modifications. Although the First Irrigation Commission attached great importance to protective works in famine stricken areas, interest in them gradually tapered off.

The Second Irrigation Commission was set up by the Government of India in 1969, under the Chairmanship of Shri Ajit Prasad Jain, the then Member of Parliament. The terms of reference were (a) to review irrigation development in India, (b) to recommend essential irrigation works in the chronically drought affected areas and food deficit areas, (c) to draw up a broad outline of irrigation development for achieving self sufficiency in food crops and (d) to suggest criteria for sanction of irrigation projects.

That Commission inter-alia suggested the need for conjunctive use of surface and ground water, preparation of complementary programmes covering engineering works, watershed management and ayacut development and also recommended constitution of seven River Basin Commissions for the whole country to oversee all water resources development. Keeping in view the social urges and the demand for the removal of regional and social disparities, the Commission recommended construction of minor works in a time bound framework in under-developed areas. In order that irrigation in India should pay for itself, the Commission recommended that the water rates should be raised to a level sufficient to cover the cost of maintaining and running the works and a reasonable rate of interest on investment. It also advocated the use of computers for the collation of irrigation and agriculture statistics in order to provide the latest information to irrigation planners.

The Irrigation Commission supported the adoption of B:C Ratio criteria in sanctioning projects as practised then. However, it also recommended that the practice of accepting projects with B:C ratio more than 1.5 be relaxed in the case of drought areas with a lower limit of 1.0. The Commission also recommended the setting up of a High Level Authority, " The National Water Resources Council", to take policy decisions for the conservation, utilisation and interbasin transfers of water; to lay down priorities for the use of water; to keep a continuous watch on the working of the River Basin Commissions and problems of inter-state rivers and to ensure that the formulation and execution of irrigation projects were in accordance with the highest national interest.

The Commission further highlighted the importance of soil conservation in protecting the watershed and, therefore, recommended adoption of such measures as afforestation, pasture development, protection of river fringes, road sides and the shore lines of the reservoir and the control of forest fires. Similarly, the concept of participatory irrigation management by constituting water users' associations was another important recommendation for economical and efficient use of water resources. The Commission also suggested that a special administrative agency for the coordinated and expeditious development of command area under the medium and major projects was necessary and each project should have a separate ayacut development agency. These recommendations were taken into consideration from time to time during the subsequent Plan Periods.

4.2 Development of Irrigation under the Plans

In the First Five Year Plan (1951-56), the country launched a major irrigation programme. A number of Multipurpose and Major Projects were taken up, such as Bhakra Nangal, Nagarjunasagar, Kosi, Chambal, Hirakud, Kakrapar and Tungabhadra. Simultaneously, minor irrigation schemes including ground water were given emphasis under the Agricultural Sector, along with financial assistance from the Centre.

During the periods of Second Five Year Plan(1956-61), Third Five Year Plan (1961-66) and the Three Annual Plans (1966-69), irrigation programmes were being implemented with new starts.

During the Fourth Five Year Plan (1969-74), the emphasis was shifted to the completion of ongoing projects, integrated use of surface and ground water, adoption of efficient management techniques and modernization of existing schemes. The new starts, however, continued.

During the Fifth Plan (1974-78), Command Area Development Programme was launched as a Centrally Sponsored Scheme with the objective of reducing the lag between potential created and optimum utilization of available land and water. The programme was conceived as a means of co-ordinating all related activities to meet with these objectives under one umbrella. Initially, 60 Major and Medium projects were covered with a CCA of 15 Mha.

During the Annual Plans of 1978-80 and the Sixth Five Year Plan (1980-85), new starts continued and at the end of Seventh Plan, there were as many as 182 major and 312 medium ongoing projects requiring an estimated amount of Rs.39,044 crores at the 1990-91 price level for their completion. New starts were, therefore, restricted considerably and greater emphasis was laid on completion of projects, which were in the advanced stages of completion (those with an expenditure of 75 percent or more). This was continued during 1990-91, 1991-92 Annual Plans and the Eighth Five Year Plan (1992-97). Rehabilitation and modernization of old irrigation schemes gained momentum. User's participation in major and medium irrigation schemes received greater attention. Repairs and improvement to the minor irrigation projects, as a part of integrated micro-development, also received encouragement. Similarly, sprinkler and drip irrigation programmes and the conjunctive use of surface and ground water gained momentum. The projects completed, along with minor irrigation and ground water development, have created an estimated potential of about 90 Mha, by the end of the Eighth Plan.

Details of Planwise investment and potential created and utilized are given in Tables 4.1 and 4.2.

Table – 4.1

Magnitude & Composition of Investment through Plan Periods in Irrigation and Flood Control Sectors

(Rs. in crore at current price level)

Plan	Major/ Medium Irrigation.	Minor Irrigation			CAD	Flood control	Total
		Public Sector	Institutional Finance	Total Finance			
First (1951-56)	376.24 (7803.42)	65.62 (1360.99)	Negligible	65.62 (1360.99)	-	13.21 (273.98)	455.07 (9438.39)
Second (1956-61)	380 (6013.98)	142.23 (2250.97)	19.35 (306.24)	161.58 (2557.21)	-	48.06 (760.61)	589.64 (9331.80)
Third (1961-66)	576 (6674.84)	327.73 (3797.82)	115.37 (1336.94)	443.10 (5134.76)	-	82.09 (551.28)	1101.19 (12760.88)
Annual (1966-69)	429.81 (3943.90)	326.19 (2993.10)	234.74 (2153.96)	560.93 (5147.06)	-	41.96 (585.02)	1032.70 (9475.98)
Fourth (1969-74)	1242.30 (7976.41)	512.28 (3289.18)	661.06 (4243.45)	1173.34 (7532.64)	-	162.04 (1040.40)	2577.48 (16549.18)
Fifth (1974-78)	2516.18 (12519.42)	630.83 (3138.74)	778.76 (3874.67)	1409.58 (7013.41)	-	298.61 (1485.75)	4224.36 (21018.59)
Annual (1978-80)	2078.58 (7949.67)	501.50 (1918.02)	480.40 (1837.32)	981.90 (1388.16)	362.96 (1388.16)	329.96 (1261.95))	3753.40 (14355.15)
Sixth (1980-85)	7368.83 (19625.50)	1979.26 (5271.39)	1437.56 (3826.67)	3416.82 (5100.06)	743.05 (1978.97)	786.85 (2095.63)	12315.55 (32800.16)
Seventh (1985-90)	11107.29 (21207.15)	3118.35 (5953.87)	3060.95 (5844.27)	6179.30 (11798.14)	1447.50 (2762.85)	941.58 (1797.76)	19675.67 (37566.77)
Annual (1990-92)	5459.15 (8125.60)	1680.48 (2501.29)	1349.59 (2008.78)	3030.07 (4510.07)	619.45 (922.01)	460.64 (685.63)	9569.31 (14243.32)
Eighth (1992-97)	21071.87 (31057.63)	6408.36 (9445.22)	5331.00 (7857.31)	11739.36 (17302.52)	2145.92 (3162.85)	1961.68 (2493.35)	36648.83 (54016.36)
Total upto the end of 8th Plan at current prices	52606.25 (132389.93)	15692.83 (39492.89)	13468.77 (33895.77)	29161.60 (73388.66)	5418.88 (13385.66)	4856.67 (12222.39)	91943.40 (231386.59)
Ninth Plan (1997-2002) (Anticipated at current prices	43034.96	9314.84	-	-	3012.79	1078.52	56441.11 *

** - Public Sector outlays only*

Source: Reports of the Working Groups of Ninth Five Year Plan.

Note: Figures within brackets above indicate the expenditure at constant prices of 1996-97 level.

Table-4.2

Development of Irrigation Potential (Cumulative) Through Plan Periods

(In Mha)

Plan	Major/Medium Irrigation		Minor Irrigation		Total Irrigation		Gross Irrigated Area as per Land Use Statistics
	* Pot	** Utl.	Pot	Utl.	Pot	Utl.	
Pre-Plan	9.70	9.70	12.90	12.90	22.60	22.60	22.56
First (1951-56)	12.20	10.98	14.06	14.06	26.26	25.04	25.64
Second (1956-61)	14.33	13.05	14.75 @(8.28)	14.75 (8.28)	29.08	27.80	27.98
Third (1961-66)	16.57	15.17	17.00	17.00	33.57	32.17	30.90
Annual (1966-69)	18.10	16.75	19.00 (12.50)	19.00 (12.50)	37.10	35.75	35.48
Fourth (1969-74)	20.70	18.69	23.50 (16.44)	23.50 (16.44)	44.20	42.19	40.28
Fifth (1974-78)	24.72	21.16	27.30 (19.80)	27.30 (19.80)	52.02	48.46	46.08
Annual (1978-80)	26.61	22.64	30.00 (22.00)	30.00 (22.00)	56.61	52.64	49.21
Sixth (1980-85)	27.70	23.57	37.52 (27.82)	35.25 (26.24)	65.22	58.82	54.53
Seventh (1985-90)	29.92	25.47	46.61 (35.62)	43.12 (33.15)	76.53	68.59	61.85
Annual (1990-92)	30.74	26.32	50.35 (38.89)	46.54 (36.25)	81.09	72.86	65.68
Eighth (1992-97) (anticipated)	32.96	28.44	56.60 (44.35)	52.32 (41.50)	89.56	80.76	70.64
Ninth Plan (1997-2002) (Proposed)	42.77	36.15	63.84	57.24	106.61	93.39	-

* Pot : Potential created

*** Utl : Utilisation achieved*

@ Component of ground water

Figures in Brackets indicate the potential created/utilised by ground water development

Source : Ministry of Water Resources and Reports of Working Groups and Ninth Five Year Plan Proposals of Various States.

Note: Upto the Annual Plan 1978-80, the potential created and its utilisation for minor irrigation are shown as same. In this context, it is to be mentioned that as per procedure upto Fifth Plan, the utilisation of potential was reckoned as 100 percent of potential created. However, the PAC in its 141st Report (1982-83) did not accept the above practice. Subsequently, the Working Group on Minor Irrigation for the formulation of Seventh Plan recommended that during the Sixth Plan, the utilisation figures might be reported as per existing practice but the base line for the year 1984-85 should be worked out both for potential created and utilised. Accordingly, after consultation with the states, the Planning Commission fixed the base figures for 1984-85 for potential created and utilised as 37.52 Mha and 35.25 Mha respectively.

The Ninth Plan

The overall strategy of irrigation development and management during the Ninth Plan has the following core ingredients :

- To improve water use efficiency by progressive reduction in conveyance and application losses,
- To bridge the gap between the potential created and its utilisation by strengthening the Command Area Development Programme (CADP), institutional reforms and promoting farmers' involvement in irrigation management,
- To complete all the ongoing projects, particularly those which were started during pre-Fifth Plan and Fifth Plan periods as a time bound programme to yield benefits from the investments already made ,
- To restore and modernise the old irrigation systems which were executed during the pre-independence period and 25 years ago,
- To introduce rational pricing of irrigation water, based initially on O&M cost and then to encourage higher level of water use efficiency,
- To take concrete steps towards comprehensive and integrated development of natural water resources, taking into account the possibility of inter-river basin transfer of surplus water,
- To promote adaptive research and development to ensure more cost effective and efficient execution and management of irrigation systems,
- To promote Participatory Irrigation Management (PIM) with full involvement of the water user community, which will be at the centre stage of implementation of above strategies of the Ninth Plan,
- To encourage and implement the conjunctive use of ground and surface waters towards optimal utilisation of water resource and to have its development environmentally sustainable as well,
- To accelerate the development and utilisation of ground water, particularly in the eastern region on sound technical, environmental and economic considerations along with proper regulatory mechanisms.

The physical targets set in the Ninth Plan are given in Table 4.3.

Table - 4.3

Targets	Additional Irrigation Potential, Mha	Additional Utilisation, Mha
Major/Medium	9.81	8.71
Minor	7.24	4.93

Source : Ministry of Water Resources and Reports of Working Groups and Ninth Five Year Plan Proposals of Various States.

The outlay fixed for all irrigation projects in the Ninth Plan is Rs.56,441 crores. It is most unlikely that the physical targets would be achieved with this order of outlay.

4.3 Categories of Irrigation Projects

Irrigation Projects are classified under three categories, namely major, medium and minor depending upon the extent of CCA.

Major Irrigation Projects	:	Those having C.C.A. of 10,000 ha or more.
Medium Irrigation Projects	:	Those having C.C.A. between 2,000 ha to 10,000 ha.
Minor Irrigation Projects	:	Those having C.C.A. of 2,000 ha or less.

The development programmes under different categories of irrigation projects are briefly discussed below:

Major & Medium Projects

Ultimate potential for this category is assessed as 58.46 Mha. The achievement as anticipated upto 1996-97 has been 32.96 Mha (potential created)and 28.44 Mha (potential utilised). A number of river valley projects which are multipurpose projects in character envisaging irrigation and other benefits such as hydro power, flood control and water supply include major projects as an important component. There are also single purpose major irrigation projects.

The irrigation facilities created through major irrigation projects are more dependable with greater reliability ranging from 75 percent to 90 percent. Large blocks of irrigation command under major projects lent themselves to establishing Command Area Development Authorities comprising number of disciplines for management of canal net work below the Government outlet and on-farm works including supply of water through Warabandi and other activities such as providing other agricultural inputs for the integrated development of the command area. Major/Medium Project Irrigation facilities have been a great asset to the country and have proved to be the sheet anchor to the sustainability and reliability of overall food production which is insulated from recurring droughts and floods. The cost of development so far is estimated at Rs.52,606 crores at current prices during the last 47 years. This works out to Rs.15,960 per ha.

Minor Irrigation Schemes

(a) Surface Water Minor Irrigation Schemes

These schemes comprise mainly tanks, small diversion works and small lift irrigation schemes. They are more conspicuous in undulating and hilly regions of the country and are spread all over the country. During the pre-plan period, they were the principal source of irrigation. They significantly meet the need of irrigation in chronic drought affected areas and help in recharging of ground water. The total ultimate irrigation potential from all sources of water in the country has now been assessed as 139.89 Mha. Of this, a potential of 17.38 Mha is planned to be achieved through the surface minor schemes. The total cost of development of surface minor irrigation schemes so far at current prices is about Rs.15,693 crore and this works out to Rs.12,810/ha.

(b) Ground Water Minor Irrigation Schemes

Out of the total water potential of 1,953 km^3, ground water constitutes 432 km^3 which is about 25 percent of the total. However, on utilisation side, the uses of ground water and surface water are more or less equal. Ground water development got a boost after the spread of rural electrification and the advent of high yielding varieties in the sixties. For all practical purposes, this sector is privately owned and managed as the ratio of public tubewells to private tubewells is 1:73 and total number of dug wells is about 10 million (all in private sector - year 1995).

About 50 percent of the total irrigation done in the country is through groundwater. It is seen that the groundwater potential created has increased from 6.5 Mha at the end of the pre-Plan period to 44.35 Mha by the end of the Eighth Plan. The corresponding utilisation increased from 6.5 Mha to 41.50 Mha. The exploitation of groundwater has been quite uneven in the country and Gujarat, Tamil Nadu, Punjab and Haryana are amongst the states where large ground water development has taken place. In the eastern region, groundwater development is quite low, namely eight percent in Orissa, nine percent in Bihar, 20.5 percent in Assam and 34 percent in Eastern Uttar Pradesh. Groundwater in this area is available at a depth of 5 to 10 m. There is scope of exploitation of ground water by means of shallow tubewells. However, copious rainfall has a negative influence on the use of groundwater in the eastern region because of flooding and low demand for about six to eight months in a year.

(c) Conjunctive Use of Surface and Ground Water

Source of water for both the surface and ground water is the same, namely precipitation. Conjunctive use can be defined as management of all water resources in an area including surface and ground water in harmonious manner such that the total water use in the area over a period of time is optimised. Normally under such use, combined availability of water is more than the availability from separate components of surface and ground water system. Conjunctive use mitigates the problems of high water table and salinity resulting from canal irrigation and facilitates the use of high salinity groundwaters by dilution which cannot otherwise be used directly.

Command Area Development Programme

Presently there are 226 projects under this programme with a CCA of 21.95 Mha spread over 23 States and 3 Union Territories.

The components of the programme are on-farm development, construction of field channels and field drains, land levelling and shaping and implementation of Warabandi (rotational water supply). The components also include introduction of suitable cropping pattern, promotion of conjunctive use, maintenance of drainage systems, modernisation and maintenance of micro systems.

The activities under the programme are funded from three sources, namely State outlays, Central assistance on matching basis with states as grant or loan for certain selected activities and Institutional finance. A few activities of the programme are eligible for Central assistance fully in the form of grants; however, the financing pattern for such Central assistance has been undergoing change over time. An amount of Rs.1,991 crore has been released to the states as the Central assistance from 1974-75 to March, 1999.

Under the CAD Programme certain special activities are also taken up such as demonstrating scientific technology covering scientific water management, land development, introduction of suitable crops and varieties, proper doses and method of application of fertilisers, irrigation practices etc. The farmers are provided practical training on these aspects.

4.4 Review of Programmes and Performance

The figures of assessed ultimate irrigation potential are given in Table 4.4.

It is seen that as compared to the ultimate figures, the irrigation potential created by 1996-97 in respect of major and medium projects was 55.9 percent, while for minor projects it was 71.4 percent

Table –4.4

Cumulative Irrigation Development in the Plan Periods

(In Mha)

Item		Pre-plan upto 1951	Upto Annual Plan 1996-97	Ultimate Potential	Created irrigation potential as percentage of ultimate
(a) Major & Medium Irrigation	Potential	9.70	32.69	58.46	55.9
	Utilisation	9.70	28.20		
(b) Minor Irrigation					
(i) Surface water	Potential	6.40	12.25	17.38	70.5
	Utilisation	6.40	10.82		
(ii) Ground water	Potential	6.50	45.88	64.05	71.6
	Utilisation	6.50	42.05		
Total of (b)	Potential	12.90	58.13	81.43	71.4
	Utilisation	12.90	52.87		
Grand Total (a) + (b)	Potential	22.60	90.82	139.89	64.9
	Utilisation	22.60	81.07		

Performance of Major and Medium Projects

The achievement in creating irrigation facilities through major and medium irrigation projects was largely through development of indigenous technology in planning, designs and implementation of large river valley projects, many of them multipurpose in character with benefits of irrigation, hydro power, flood control and fisheries development. Indian engineers planned and designed dams and irrigation systems with totally indigenous knowledge by setting up Designs Organisations in the States and at the Centre. The Central Water and Power Commission functioned as a pivotal organisation providing guidance in designs. Appropriate technologies were evolved. Irrigation and hydraulic research institutions were set up. Local materials were used to the extent possible. Human resource training was given with special attention to create large number of professionals needed for investigations, explorations, research and to prepare project reports and designs. India also excelled in heavy engineering works with setting up of workshops and factories for manufacturing of heavy earth moving equipments initially with import components which gradually got reduced to almost nil. Simultaneously, there was growth of resourceful construction agencies using heavy earth moving equipments with mechanisation of various activities which expedited the speed of construction.

Today, India possesses know-how of appropriate technologies in the development and management of water resources in general and irrigation in particular suited to the conditions of developing countries and is providing consultancy services in this sector abroad. Indian expertise was enriched by IDA assistance by World Bank and by aid from other multilateral/bilateral agencies for irrigation projects, initially on Project to Project basis but later on, on a programme basis.

While reviewing the performance of major and medium projects, the following issues have to be mentioned:

Delays in construction of Projects

In the five decades of planned development, 96 major irrigation projects and several hundred medium projects were fully commissioned. Experience in implementation of the projects showed that the gestation periods of the projects were unduly long leading to cost overruns of the projects. Consequently, targets fixed in many plan periods could not be achieved. Some of the reasons for non-completion of projects according to the time schedules were :

- Proliferation of schemes, inadequate plan outlays and consequent thin spreading of resources
- Pre-emption of available resources by externally aided schemes
- Cost and time overruns
- Inadequate planning & investigations and delays in planning implementation of distribution systems
- Increased provisions required for meeting the rehabilitation and environmental costs due to greater awareness of their importance
- Delays in resettlement and land acquisition including transfer of forest land
- Non prioritisation of projects

The above issues are dealt with by us in the Chapters 9 and 10.

Rehabilitation and Environmental Issues.

The last decade has been characterised by fewer new starts and a slow down in implementation of projects. Apart from the paucity of funds, this is also due to problem of rehabilitation and resettlement of Project Affected Persons(PAPs). While the policies of rehabilitation and resettlement have been made more and more liberal, there is still scope of further improvements. The National Rehabilitation Policy which is under formulation, it is hoped, would address realistically all the concerns. The various issues involved are discussed in the chapter on Water Quality and Environmental Aspects(Chapter 12).

Sedimentation of Reservoirs

This phenomenon is very important from the point of view of water available for utilisation from a storage reservoir since sedimentation reduces the benefits of a project after a certain period. This subject has also become controversial as the opponents of large dams cite this as a negative environmental factor.

Reservoirs built upto 1965 were designed on the basis of sedimentation rate of 3.57 to 4.76 ham per 100 km^2/ year and the dead storage was generally designed to provide fully useful life of 100 years for the reservoir. The capacity surveys undertaken during 1958- 65, however, revealed that the siltation rate was higher during the first phase of operation and thereafter, it had fallen significantly. The deposited sediment also gradually gets denser and reduces in volume. Now a days, the practice is to estimate sedimentation rate based on measured sediment load data collected at key hydrological stations on various rivers. The sediment load observations are correlated with the sedimentation rates for similar catchments observed on the basis of actual surveys for existing dams. The live storage is being so planned that the envisaged benefits do not get reduced over a period of 50 years (full service) life for irrigation and 25 years for hydropower, as a result of sedimentation. The outlet levels are also planned such that sedimentation does not cause any operational problems for 100 years. The Ministry of Agriculture and Irrigation (Department of Irrigation), GOI set up a Reservoir Sedimentation Committee in February, 1978. The Committee made recommendations on long term measures such as catchment protection, soil conservation and afforestation. It also recommended collection of sediment data in all major river systems and establishment of a data bank. Watershed Development on a country wide basis, as recommended by us in Chapter 6 would, in a large measure, reduce the sedimentation of reservoirs.

The CWC has computed the loss in capacity of 46 reservoirs upto the year 2025 and 2050 and on this basis, we have arrived at a total loss in the live storage capacity as 65 km^3 in the year 2050 for the existing, ongoing and future storages, which works out to be about 17 percent of the total live storage capacity.

Removal of silt from the reservoirs has been engaging attention since long. A cost-effective method of removal of silt has yet to be devised. Desilting of reservoir is project specific. However, research efforts are required for development of economic technologies for the purpose.

Regarding the negative impact of sedimentation, it is argued that silt which has a manurial value for the areas getting flooded in the downstream reaches would no more be available depriving those areas of the benefit. However, with the absorption of silt in the reservoir, the flooding of the downstream area gets reduced significantly as the relatively silt free water flowing in the lower river channel picks up silt from the downstream reach, thus increasing the capacity of channel to carry discharge. This reduces flood damage. Further, the storage provided behind the dam also reduces both the intensity and frequency of the floods.

Other relevant issues

The experience during the post independence period has shown that there are certain vital areas which have to be addressed with much greater attention not only to bridge fully the gap between the created potential and its utilisation but also to ensure more economical and efficient use of water, more intimate involvement of the users through their active participation in management, equitable distribution of irrigation water and prevention of adverse effects of irrigated agriculture like waterlogging, soil salinity, deterioration in water quality due to use of chemicals, overdrawal of ground water, health hazards and impact on environment etc. These issues are dealt with by us in appropriate chapters.

Minor Irrigation (Surface Water) Schemes

The irrigation potential under surface minor irrigation works has doubled in the last 47 years. Minor irrigation works have high rate of depreciation due to silting. The benefits, therefore, get reduced progressively. As they depend on small local catchments, they are more prone to be affected during droughts. In relation to the limited storages, their surface areas are usually large with excessive evaporation losses. However, these works serve an important purpose for recharge of ground water and provide the only means of irrigation to the chronically drought affected areas. Where flow irrigation is not economically feasible, lift irrigation schemes are planned. The need of the hour is to take a total performance evaluation of the surface minor irrigation schemes in each state especially with regard to silting, live capacity available, adequacy of irrigation net work including control structures and equity and timeliness of supply of water. Based on this, a modernisation programme should be prepared.

Ground Water Minor Irrigation Schemes

These works comprise dug wells, dug cum bore wells, private tubewells and public tubewells using electrical pump sets or diesel pump sets. Groundwater development achieved a spectacular success with the potential increasing more than six times during the last 47 years. The development is primarily achieved through individual and co-operative efforts with the help of institutional finance or investment by farmers from their own savings and resources. The bulk of institutional finance is mobilised through land development banks, commercial banks and State co-operative banks with refinance from NABARD. Public sector outlay has been very limited. Ground water exploitation involves use of energy, which is also scarce and costly. Even so, in water scarce areas, tendency towards over-exploitation is persistent. Admittedly, subsidised power for farming has given a boost to lift irrigation and ground water development.

Monitoring and preservation of use-worthy quality of groundwater is an important aspect which requires serious attention. Over-exploitation of groundwater leads to the deterioration of its quality. Another source contributing to the deterioration is the deep infiltration of surface water from irrigated fields using chemical fertilisers and pesticides. Deep infiltration from saline soils also adds to the salinity of groundwater. Further, discharge of effluents from industries and sewage plants also finds its way to the groundwater either through deep percolation from the ground surface or by seepage outflow from the rivers and drainage channels into which such effluents are discharged.

The problem of inadequate and erratic supply of electric power for exploitation of ground water has been a major one. Rural feeders need to be strengthened and power generation capacity needs to be increased to meet the agricultural loads. The pumping of water with diesel sets has been found to be quite costly - the cost is almost double that of electric pumping. All such measures, however, need to be implemented under a proper legal framework of exploitation of ground water, otherwise unregulated and reckless pumping will cause more damage not only to others who are deprived of water but also to the farmers who pump excessive water. Legal issues regarding water including ground water have been discussed in Chapter 8 on ' Legal and Institutional Framework'. The data on ground water extractions especially by private wells/ tubewells and ground water tables, quality of water and type of water use are not reliable and there is need to evolve a satisfactory system.

Command Area Development

Evaluation studies sponsored by the Ministry of Water Resources in order to assess the impact of CAD Programme reveal that there has been a positive impact of the programme on improvement in irrigation water utilisation, increase in irrigation intensity and water use efficiency, increase in agricultural productivity and production, improvement in the soil and water environment through efficient water management and drainage activities etc.

Due to over-lapping of modernisation and other water improvement programmes being implemented pari- passu with CAD programmes, it is difficult to determine the precise impact of CAD programme alone, but it is clear from several case studies that the programme has made a contribution to increase in utilisation, improvement of irrigation intensity and water use, change in cropping pattern and increase in yields and farm income. In some areas it has helped to reduce adverse environmental impact.

However, the main emphasis of CAD activities has so far been on physical works such as construction of field channels, field drains, OFD works and land levelling. Not much attention has been paid to field drains both in regard to their construction as well as maintenance. Although a model organisational structure for CAD was recommended by the Ministry of Water Resources, the posts were not filled up in many states and it is observed that there are frequent transfers of personnel. As a result, team work is not developed amongst different disciplines. Some crucial disciplines like agronomy, social science are not inducted into the management. Another area which calls for action is the extension services and management of demonstration farms. Promotion of agro industries should also constitute an important activity.

CAD has not also carried out diagnostic analysis and implemented measures to improve water use efficiency and agricultural production.

Several studies have also indicated that the weakest aspect is the non-involvement of the farmers in the programme and the general 'paternalistic' approach of State Water Resources Department. This has to be remedied through Participatory Irrigation Management (PIM) and formation of users' bodies and ensuring their involvement from the very beginning.

4.5 Gap Between Potential and Utilisation

One of the major criticisms of irrigation management is about the large gap between potential created and its utilisation . This gap, which has persisted since long, must be reduced to the minimum. The reasons leading to the lag in utilisation have to be gone into. The objective should be to devise a system under which correct figures of potential and utilisation are reported and measures recommended for reducing the period of lag in utilisation.

For the purpose of the analysis, the period 1979-80 to 1994-95, upto which the latest figures of Land Use Statistics are available, is selected. The year 1979-80 marks the beginning of the reporting of utilisation figures for minor irrigation works. Earlier, utilisation of minor irrigation works was assumed to be equal to potential created (Please see the footnote below Table 4.2).

Normally, irrigation potential created during a particular year cannot be fully utilised during that year. The utilisation develops gradually attaining its full value by the end of about five years. If we assume that fresh potential created every year during a five year period is the same and the utilisation develops at 20 percent every year, it can be worked out that at the end of the five year period, additional utilisation will have been 60 percent of the new potential created during that slot of five years. From this consideration, we examine the figures of potential created and utilised during the seventh plan period (Table 4.2). It is seen that at the beginning, the cumulative irrigation potential created was 65.22 Mha. Full utilisation of this should have been obtained by the end of the Plan in 1990. In addition, 60 percent of the new potential (11.31 Mha) added during the Seventh Plan period should have been utilised. Thus, the total utilisation should have been 65.22 + 0.6 (11.31) = 72 Mha. As compared to this, the actual utilisation was 68.59 Mha. The gap of 3.41 Mha is therefore such as could have been avoided by undertaking suitable structural and managerial measures. The issue, therefore, requires critical examination.

Table – 4.5

Cumulative Statistics of Irrigation in India (All States Together)

(All figures in Mha.)

Sl. No.	Categories	Ultimate Irrigation Potential	Potential created at the end of			Utilisation achieved at the end of			Lag between potential created and utilisation			Gross Irrigated area as per Land Use Statistics
			1979-80	1994-95	1995-96	1979-80	1994-95	1995-96	1979-80	1994-95	1995-96	1994-95
1	Major & Medium	58.46	26.61	31.82	32.20	22.64	27.45	27.74	3.97	4.37	4.46	
2	Minor Irrigation (Surface)	17.38	8.00	11.92	12.10	8.00	10.62	10.72	-	1.30	1.38	70.64
3	Minor Irrigation (Ground water)	64.05	22.00	42.93	44.42	22.00	39.63	40.83	-	3.30	3.59	
	Total	139.89	56.61	86.67	88.72	52.64	77.70	79.29	3.97	8.97	9.43	70.64

Source: Water Related Statistics, CWC - 1998

Table 4.5 gives lags in utilisation of potential under the above three categories at different times. It also gives the figures of irrigation as per the land use statistics for the year 1994-95. It can be seen from the Table that for major/medium schemes, the lag of 3.97 Mha in 1979-80 has slightly increased to 4.75 Mha in 1995-96. It appears higher figures are reported at the end of the year in which potential is developed but later on the figures are reduced. The possible reasons for reporting such figures of potential created and utilisation may be:

Non verification of actual CCA on ground vis-à-vis that worked out from project records.

Lack of Uniformity in Reporting Potential

There is no uniformity about the definition of irrigation potential all over the country. Some states report net potential while some report gross annual potential. Again, some report the areas covered down to the end of government channels, while others report the potential only when the field channels are constructed. Secondly, areas are often reported even if part systems are completed but water is not able to flow due to some physical constraints (non- availability of an intermediate patch of land or non-completion of an on-line structure etc.)

The irrigation potential connotes the capability for providing irrigation facilities to an area (gross, counting double cropping also) if full requirements of water are met. If any difficulty is found from supply side, this may be mentioned while reporting the figures of potential created.

Lack of Uniformity in Reporting Utilisation

There is no uniformity in reporting the utilisation figures also. As utilisation depends on availability of water, it would vary from year to year even if the system is physically complete. As such, many states report all -time maximum figures irrespective of the actual utilisation during the reported year. Normal practice has been to report utilisation figure corresponding to the maximum area irrigated in last five years. Sometimes, full utilisation for crop season is reported even if only one or two waterings have been supplied.

Unauthorised use of water, either within the command through unauthorised outlets or through lifting water from the canals outside the command, has of late become a common practice. Such use, on one hand, does not get reflected in the statistics and on the other hand, creates difficulties in water distribution.

Lower Utilisation Due to System Deficiencies and Non-availability of Water from Supply-side

It is, therefore, necessary to draw up definite guidelines for reporting the potential created and the utilisation achieved so that there is uniformity amongst all the states. It will be possible to carry out critical review of the physical and operational performance for each project only then. This procedure will also help to identify the deficiencies and bottlenecks, if any, in effecting further utilisation of the potential and arriving at the appropriate remedial measures.

We recommend that the term 'irrigation potential created' by a project at a given time during or after its construction be defined as the aggregated gross area that can be irrigated annually by the quantity of water which could be made available through infrastructure completed upto last government outlet in the water delivery system.

A uniform reporting system for potential utilised is also necessary. We recommend that the term 'irrigation potential utilised' be defined as the total gross area actually irrigated by a project during the year under consideration. The figures relating to the stabilisation of 'old areas' should be furnished separately since these will not be additive to the gross area irrigated. As, generally, the utilisation of irrigation potential created can take place only in the year following the creation of such potential, it will be appropriate if the irrigation potential utilised in particular year is considered with the potential created upto the end of the preceding year for the purpose of comparison.

As mentioned earlier, there is also need for periodical re-appraisal of the potential of irrigation projects on the basis of updated availability of water on a sustainable basis, increased potential of irrigation on the basis of modernisation of canal systems which may have been carried out after the project was commissioned and on the basis of actual CCA commanded under each outlet as mentioned above. Similarly, there is need to critically examine the figures of actual irrigation. This is very important because this would reveal the true picture regarding the lag in utilisation and would provide a scientific and rational basis for devising measures to accelerate the utilisation of the potential created and make improvements in strategies of reforms by CADA. For this, a special drive is recommended so that the field officers report actual position in standardised format. If the above exercise is carried out under proper technical supervision and verification, the reassessed value of the potential will be known for each project and the lag between potential and utilisation might reduce considerably, thus reconciling the anomaly to a large extent and reflecting the true time lag for utilisation of the potential created. Normally, it should not take more than five years for utilising the potential created, especially with the stage of present infrastructure development, namely the CADAs, field channels excavated right down to the field and agricultural extension and field demonstration facilities etc.

As regards minor irrigation, attention is drawn to the note below Table 4.2. At the end of 1994-95, potential of 11.92 Mha is reported while the utilisation is 10.62 Mha, giving a lag of 1.3 Mha(Table 4.5). The potential figure is fluctuating between 11.0 and 12.2 Mha for the last nine years with no definite trend and the utilisation figures have also fluctuated between 10.00 and 11.0 Mha. There is, if at all, very little addition to benefits. The Government expenditure, however, on surface minor irrigation is being incurred at a rate of about Rs. 400 crores (at constant price 1980-81 = 100) each year. The Ministry of Water Resources may go into the matter as to why utilisation and potential have more or less stagnated while expenditure continues to increase. The expenditure figures may include costs on tanks as well as government tubewells. This also raises a doubt whether the assessed ultimate potential under surface and ground water minor irrigation is realistic. It is known that minor irrigation tanks get rapidly silted up and their storage capacity gets reduced with passage of time. The figures of potential created may not reflect the reduced potential of existing minor tanks. Thus the lag would seem to increase while in reality the same may be less. This is an important issue which needs to be gone into for each state and the present potential as well as the utilisation require to be reassessed along with ultimate potential taking into consideration rehabilitation and improvements to existing tanks. For this purpose, special committees of irrigation managers and the beneficiaries of minor irrigation schemes may be constituted.

There is a lag in utilisation in regard to ground water also. Due to variety of ground water structures like dug wells, dug cum bore wells and tubewells, there would be varying reasons for lag. *Here also, there is a possibility of over reporting of potential because, after the well is dug, it may run dry subsequently. In such a situation, the potential is not deleted but the new dug well would add its own potential. Similarly, for tubewells, the distribution system, either piped or open channels (lined or* unlined), may not be ready by the time the tube-well is harnessed or vice-versa. In ground water schemes, therefore, the potential figures may not be firm. It appears desirable to go by the figure of actual utilisation, *though the figures of utilisation reported would be figures of maximum utilisation as for major/ medium schemes. Since most of the investment is in private sector through institutional finance,* the data base may also be very weak. It is, therefore, recommended that a firm data base should be *established by carrying out a district-wise and village-wise census of ground water utilisation in the past* five years.

There is also difference between the figures of utilisation as reported by the State Governments and those indicated by the Land Use Statistics. If we take the figures of 1994-95, the gross area irrigated as per the Land Use Statistics is 70.64 Mha while that reported by Irrigation Departments is 77.7 Mha. There is, thus, a difference of nearly 7.0 Mha which needs reconciliation. No serious attempt appears to have been made in the past to find reasons for the difference. The possible reasons are:

- In Irrigation Department statistics, the utilisation is not taken as actual utilisation in the reporting year but as maximum utilisation of irrigation in previous five years. Thus, the figures reported are higher.

- If a farm is partly irrigated by surface water and partly by ground water in the same crop season, the same may have been double counted for both surface and ground water by the state authorities while reporting the figures.

- For minor irrigation, especially wells, the figures reported by the states may not be accurate. For instance, in the case of ground water, the percentage of mortality assumed for calculation may be much lower than the actual mortality in the field.

- Figures reported by State Governments do not often tally with demand statements prepared for levy of water charges. In such cases, demand statements should be taken as correct.

This subject, however, requires further investigation to find out the reasons with a view to recommending the guidelines for reconciliation of the figures. It would be desirable to reconcile the figures at the State level by arranging co-ordination between the departments concerned.

Specific review should be attempted to find out methodologies adopted by the departments collecting the statistics. Irrigation, Revenue and Agricultural departments who collect and compile land use statistics may reconcile the figures adopting uniform criteria regarding identification and annual reckoning of area of irrigation. Use of satellite imageries should also be made for assessment of irrigated areas in different seasons by proper interpretation of imageries.

4.6 Waterlogging

Waterlogging and salinity are major problems in some areas and are citedas the consequences of irrigation. There are many causes for waterlogging and salinity. Waterlogging may be caused by natural or man-made causes:

Natural causes

- Poor natural drainage as a consequence of topography or unfavourable sub-soil conditions like existence of hard-pan at shallow depths.
- Spilling of rivers resulting in temporary or seasonal inundation.
- Heavy rainfall, storm surges, estuarine flow, high tides coupled with poor natural drainage.
- Excessive infiltration in higher table lands appearing in low-lying lands through permeable sub-strata.

Man-made Causes

- Developmental activities such as construction of roads, bridges, canals, flood levees, railway embankments, buildings etc. causing impediment to natural drainage.
- Seepage from canals, distributaries, minors and water courses / field channels and leaking structures across canals.
- Supply and application of irrigation water to crops much beyond their evapo-transpiration (ET) requirement i.e. high water allowances.
- Lack of conjunctive use of canal water and groundwater, due to faulty pricing and policies.
- Lack of motivation for night irrigation.
- Poor on-farm water management.
- Inadequate drainage system and deficient maintenance of existing drainage infrastructure.
- The problem of soil salinity develops in the irrigation command when there is rise in the water table. The salinity/alkalinity may occur due to one or a combination of following factors :

- Accumulation of salts due to salty surface or ground water used for irrigation.
- Upward movement of salts with capillary rise from lower layers.
- Use of sodic water for irrigation.
- Ingress / intrusion of the sea water.
- High ET demands and low level of salt uptake.
- Inadequate dose of freshwater, to counter upward movement of salts.

Extent of Waterlogging

Assessment of waterlogged, saline / alkaline area in the country has been carried out at different times by different experts and agencies. Reported figures vary widely. This is because each Agency adopted its own norms for defining waterlogging and salinity / alkalinity. Also, some reports include unirrigated and / or coastal saline areas.

The National Commission on Agriculture (NCA) assessed that an area of about 6.0 Mha was waterlogged which included the areas in irrigation command and unirrigated land as well. Out of this assessment, an area of 3.4 Mha was estimated to be suffering from surface water stagnation and 2.6 Mha through rise in water table. As per the revised estimate of Ministry of Agriculture in 1984-85, the waterlogged area was 8.53 Mha, both under irrigated and unirrigated areas in the country. The Working Group set up by Ministry of Water Resources (MOWR) in 1991 reported 2.46 Mha as waterlogged area in the commands of major and medium irrigation schemes as per the details given in Table 4.6.

Table-4.6

Extent of Waterlogged and Salt Affected Areas in Irrigation Command Areas as Estimated by MOWR Working Group (1991)

(thousand hectares)

State	Waterlogged Area	Salt Affected Area
Andhra Pradesh	266.40	28
Assam	NR	NR
Bihar	619.70	224
Gujarat	172.59	911
Haryana	249.00	197
Jammu & Kashmir	1.50	NR
Himachal Pradesh	0.20	NR
Karnataka	24.54	51
Kerala	11.61	NR
Madhya Pradesh	73.12	36
Maharashtra	15.35	5
Orissa	196.26	NR
Punjab	200.00	490
Rajasthan	179.50	70
Tamil Nadu	16.19	140
Uttar Pradesh	430.00	1150
West Bengal	NR	NR
Union Territories	NR	NR
Total a) thousand hectares	**2455.96**	**3302**
b) Mha	**2.46**	**3.30**

N.R. = Not Reported

Source: G.O.I., MOWR, Report of the Working Group on 'Waterlogging, Soil Salinity and Alkanity' (1991)

It is learnt that the reported affected area is only due to rise in water table and area affected due to surface water stagnation in the commands has not been included.

Another assessment of waterlogged area in canal command has appeared recently in ICAR publication (March 1997) titled Vision 2020 - CSSRI Perspective Plan. According to this assessment, the state-wise figures of affected area vary from those in Table 4.6, but the total affected area is reported to be 2.19 Mha as canal command waterlogged area, which almost tallies with the reported figure of 2.46 Mha in the Report of the Working Group of MOWR.

In order to have a realistic figure of irrigation induced waterlogged and salt affected areas, the Commission recommends that uniform criteria for assessment of waterlogged area as well as salt affected area, based on actual field work and soil tests, loss of productivity etc., be evolved. The correct definition of waterlogged and salt affected area has also to be decided taking into consideration the diversity in soil characteristics and dominant crops grown.

The nature and intensity of salinity varies depending upon the causes responsible for the formation of saline soils in different regions. Whereas in coastal belt, soil salinity is caused by sea water intrusion and inundation, the inland salinity is generally encountered in areas with high ground water tables, mostly in canal commands. More than 97 percent salt-affected area was located in seven States, namely Uttar Pradesh (35 percent), Gujarat (28 percent), Punjab (15 percent), Bihar (7 percent), Haryana (6percent), Tamil Nadu (4 percent) and Rajasthan (2 percent). The balance 3 percent salt-affected area lies in Karnataka, Madhya Pradesh, Andhra Pradesh and Maharashtra. Salt-affected area was not reported by other states.

4.7 Drainage

Removal and disposal of the excess surface and / or sub-surface water, which is harmful for crop growth, is termed as drainage. The problems of waterlogging and excess salt concentration are closely related and are often called as "twin problems". Both can be kept under control by providing adequate drainage, which is accomplished by surface, sub-surface, vertical and bio drainage systems or their appropriate combinations.

The principal benefit of providing drainage to irrigated land is that it facilitates prevention / reclamation of waterlogged areas and soil salinity leading to sustained soil and crop productivity. Worldwide experience of providing drainage to irrigated areas has clearly indicated several benefits to soil, crop, environment and socio-economic conditions. Good drainage leads to better aeration in soils and creates more favourable environment for growth of beneficial soil micro organisms and earth-worms which are conducive to better productivity. Drainage improves the soil moisture condition. Well drained soil warm up quickly and facilitates better seed germination and rapid plant growth. These and other benefits highlight the importance of drainage especially under irrigated agriculture.

One of the major environmental benefits of drainage is its positive impact on improving the health of humans, plants and farm animals. Good land drainage reduces diseases like foot rot and liver fluke, which thrive on wetland, infections for livestock, and diseases transmitted by mosquitoes to human beings. Drainage also reduces or eliminates mild infections and various root-rots of plants.

4.8 Prevention/Reclamation Measures

Various measures to minimise the risk of waterlogging and salinity such as preparation of a drainage master plan, lining of channels, provision of appropriate control structures and escapes etc. should be incorporated in the planning and design of the project before the same is approved for implementation. A detailed soil survey of the command area is essential to assess the soil capabilities for sustained irrigation. Irrigation intensities and types of crops should then be determined. This would provide a strong deterrent to development of waterlogging and salinity later on. As a rule, less water input for crops helps in preventing waterlogging. In fact, providing 80 to 85 percent of the optimal doze of water does not significantly reduce the productivity while it enhances project benefits by increasing the area under irrigation and prevents waterlogging.

With detailed soil survey and observation of ground water fluctuations, a detailed scheme for reclamation of waterlogged areas has to be prepared. Conjunctive use of ground and surface water is also an important measure for reclamation of land. Surface drainage or sub surface drainage or combination of both may be necessary for reclamation. The cost benefit analysis of a scheme of reclamation has to be worked out which must show that the benefits exceed the cost.

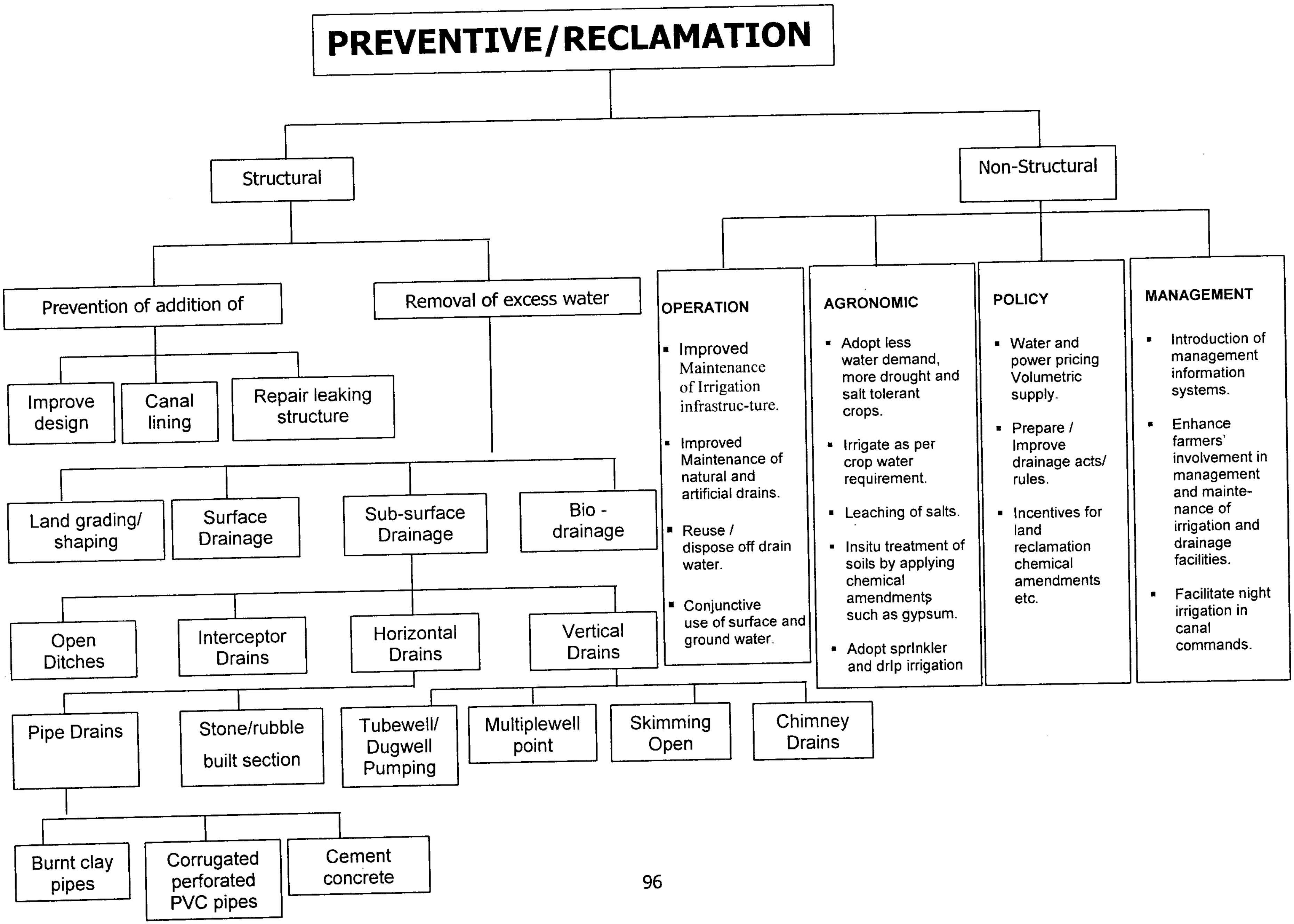
Various measures are presented diagrammatically in Fig. 4.1. Broadly, these measures are classified as structural and non-structural with various options under each category. The measures adopted in a given region may vary depending upon agro-climatic, agro-geological, and socio-economic conditions of that region.

The drainage and salinity problems of the coastal lands differ from those of inland areas and are recognised as a separate class. The coastal lowlands of India have various physiographic forms; most important are the deltaic areas of the main rivers. The coastal lowland areas in the country are 3.1 Mha, of which roughly 0.6 Mha are the mangrove forests. The largest areas of coastal lowland are found in West Bengal, Gujarat, Orissa, Andhra Pradesh and Tamil Nadu. The Maharashtra lowland area is made up by numerous small deltaic areas referred to as kharlands. Of the 3.1 Mha of coastal lowlands, 2.5 Mha are classified as saline areas and 0.6 Mha as acid sulphate soil. The drainage problems of coastal areas are related essentially to monsoon, caused by high rainfall and inadequate field, tertiary and main drainage.

Coastal salt affected soils mostly suffer from the problem of sea ingress. These areas have the problem of saline ground water. For reclamation of such areas, following steps are recommended :

- Provide embankment and sluice gates to prevent entry of sea water during the high tides.
- Construction of the coastal or peripheral bunds so that the saline runoff from the upper reach area is checked to prevent further deterioration of land.
- Rainwater harvesting should be taken up by constructing water harvesting tanks so that the good quality rain water can be utilised for providing life saving irrigation to the Kharif crops after failure of monsoon (Average annual rainfall 450-2500 mm).
- The "Dorovu Technology" developed by AICRP, BAPATLA and CSSRI, KARNAL may be implemented in the coastal area to harness the fresh water floating above saline water.
- Salt tolerant crops should be planted.
- Where the salinity is due to overexploitation of fresh water in the coastal strip as in the case of Gujarat, the overexploitation of ground water should be stopped in order to prevent mining and salinity ingress.
- Recharge of coastal areas with fresh water would help in reclamation of the lands.

Fig. 4.1 : Measures for Control of Waterlogging and Salinity



4.9 Case Studies

The direct benefits from a drainage project comprise additional agricultural production. Multiple cropping may also become possible. The Haryana Operational Pilot Project(HOPP) and the Rajasthan Agricultural Drainage Research Project (RAJAD) are successful examples of Drainage Project .

Some Successful Drainage Projects

Haryana Operational Pilot Project (HOPP)

For reclamation of water logged and saline lands in Haryana, the HOPP was started in 1994, as a collaborative project of Governments of the Netherlands, India and Haryana. The project had the following objectives : (i) Transfer of modern technology relating to reclamation of water logged and saline soils. (ii) Construction and operation of two horizontal subsurface drainage schemes, each covering about 1,000 hectares and (iii) Creating organisational capability to implement subsurface drainage systems in the states. The cost of reclamation at 1994-95 price level varied between Rs. 18,170 per ha to 29,370 per ha. The costs also include lateral collectors, sump, pump sets, pumping house and land development. The IRR was observed to increase from 13 to 20 percent and BC ratio increased from 1.26 to 1.97 for the project as a whole as a result of the drainage scheme.

RAJAD Project

The Rajasthan Agricultural Drainage Research Project (RAJAD) is a joint undertaking of the Government of India, Government of Rajasthan and Government of Canada acting through Canadian International Development Agency (CIDA). RAJAD is a large-scale research project on the use of modern subsurface drainage technology and associated water management technique in 15,000 ha of Chambal command and was initiated in 1992. Under the project, initially a total of 12 representative test sites covering approximately 1,400 hectares were selected. At the outset, five areas ranging from 50 to 180 ha viz. Daglawada, Digod, Tangpuria, Harnapur and Prempura were treated and intensively monitored. So far, sub surface drains have been installed in 10, 000 ha. A trenchless drain laying plow was imported for achieving speed as well as economy. The grade was controlled by laser. Efforts are being made to manufacture such indigenous plow in our country. The project was a success and the farmers wanted more and more area to be reclaimed.

The results of economic and financial analysis in relation to drainage co-efficient vis-a-vis drain spacing are presented in the following Table 4.7.

Table-4.7

Sub-surface Drainage Installation Scenarios in RAJAD Project

Sl.No.	Scenario	1	2	3
1.	Drainage Coefficient (mm/day)	1	2	3
2.	Drain Spacing (m)	60-70	40-60	30-50
3.	Cost/ha (Rs.)	17,000	20,000	23,000
4.	B/C Value Economic	2.30	2.37	2.55
5.	Financial	2.40	2.69	3.00
6.	Performance	Maintains salt balance; acceptable salinity control and slow salinity control reclamation; minimal waterlogging control.	Acceptable salinity control and some waterlogging control during monsoon (1 in 2 years)	Acceptable salinity control and better waterlogging control (1 in 3 to 5 years)

Source : A.K.Garg, T.P.Mathur and C.M.Tejwa – 1996 – Prioritisation of Areas for the Reclamation of Waterlogged, Saline and Alkaline Areas, Financial Implications and Phasing of Reclamation – Proceedings of National Workshop – Sponsored by MOWR, page 470-471

After reviewing the experiences of installation of various drainage systems in different States of India, the specific costs of drainage are estimated at 1990 price levels by Uttar Pradesh Land Development Corporation as follows :

Sl. No.	Drainage System	Cost (Rs./ha)
1.	Surface Drainage	7,000 to 10,000
2.	Subsurface Drainage	
	a) Manual	18,000 to 25,000
	b) Mechanised	20,000 to 35,000
3.	Vertical (Tube-well) drainage	7,000 to 10,000 (installation)
4.	Bio-drainage	11,000

Source : " Drainage Alternatives for Management of Water logged Areas" by S.K.Gupta, 1998- National Workshop on Strategy for Prevention and Reclamation of Waterlogged Areas in Irrigation Commands, New Delhi.

4.10 Tasks Ahead

In the disposal of drainage water into natural hydrological systems, care must be taken to observe that downstream beneficiaries of any surface water body (e.g. rivers, lakes) to which drainage water is added, are adequately protected. Wet lands, evaporation ponds and solar evaporators are used as discharge points when there is no direct outlet to the open surface water bodies. Disposal of drainage water into natural or man made constructions called "evaporation ponds", uses natural processes viz. evaporation, seepage and transpiration. In some advanced countries, drainage water is disposed off by "Deep Well Injection" technology where it is injected beneath the lower-most underground source of usable water, usually more than one thousand metres deep into porous rock or sand formation.

Whole-hearted and active participation by the concerned people is the *sine qua non* for the success of any developmental programme and especially for a remedial programme to counter waterlogging and salinity. Drainage works have to be performed only collectively and even if one farmer keeps away, the success of the treatment is jeopardised. Cooperation of all farmers is therefore needed, right from commencement of a drainage project.

Although the proportion of area affected by waterlogging and salinity in the country is relatively small, it may increase if proper precautions and remedial measures are not taken, especially for major projects. Sustainability of benefits is of crucial importance. The following activities would constitute a priority agenda:

- Advise farmers on the need for a shift in the cropping pattern, as it would constitute an immediate response for the areas which are either waterlogged or prone to waterlogging. More salt tolerant crops like barley, sorghum, rice etc. can be grown.
- Undertake state-wise assessment of waterlogged and salt affected area in irrigated command on the basis of uniform criteria and review of status of protected and reclaimed land in the fifth year of every five year plan for making provisions in the subsequent Financial Year Planning (FYP).
- Establish a network of piezometers/observation wells of standard density in commands of all major and medium irrigation schemes. Prepare reports on monitoring of ground water table in project commands yearly during the monsoon for mid course corrections.
- Develop appropriate drainage technology for various agro climatic zones and carry out suitable research on low cost drainage materials. The impact of drainage effluent on surface and subsurface water quality at local and regional levels, safe option for their disposal are other issues which should also receive priority.
- Develop suitable technology for reclamation and management of salt affected vertisols in irrigated command areas underlain by saline/sodic waters.
- Develop eco-friendly strategies for conjunctive use of surface and ground water to promote sustainability of crop production in a given water resources endowment.
- Establish tolerance limits of crops to deal with increased generation of poor quality waters from domestic use, drainage and agro-industrial effluents.
- Diversify farming systems and their seasonality to deal with coastal salinity.

- Within a basin, prioritization of projects based upon severity of waterlogging and salinity and further prioritization within a project command should be identified for undertaking various drainage measures.

- Set up a multidisciplinary team for each CADA to view and advise regarding the command area problems. There should be a well equipped water quality and soil testing laboratory, supported by well trained manpower for each CADA.

- Prepare drainage design manuals for engineers, and training manual for extension workers and field functionaries. Undertake a mass awareness campaign through T.V. & Radio.

- Adopt modern technology tools, wherever available and dependable such as Remote-sensing, GIS, GPS, mechanized installation of horizontal subsurface drains, use of total survey station, EM-38, computerized data keeping, use of various drainage models etc.

- Attempt an in-depth study of bio-drainage, through a Task Force to assess its potential and location specific applicability.

- Encourage investment in Drainage Industry through local manufacturers by appropriate measures, field trials and monitoring.

- Transmit to other states lessons of work at HOPP and RAJAD projects.

- Improve the overall irrigation water management to reduce costs of ameliorative measures.

- Mobilise acceptability by farmers of the suggested measures by CADA through NGOs. Ensure their involvement and participation in ameliorative measures.

- Give special attention to Human Resource Development (HRD)related to improved water management, water saving, besides prevention, control, reversal and reclamation of affected areas. Organise orientation courses for farmers to policy makers, special training courses for senior, middle, junior and grass root level functionaries. Facilities of training at CSSRI, Karnal could be obtained as tailor made courses could be offered by this organisation.

- *Finally, drainage and reclamation schemes for the entire affected area may be undertaken.* Appropriate budgetary support should be provided for this purpose.

4.11 Crop Diversification

India's agriculture is at the threshold of diversification of crops and multi cropping options. In response to the demand for commercialization of agriculture, we need to shift our focus from routine foodgrain production systems to newer cropping systems to meet the ever-increasing demand of pulses, oilseeds, fodder, fibre, fuel, spices, fruits, vegetables, medicinal and other commercial crops and make agriculture an attractive and profitable business. This has become more important today in the light of national policy of economic liberalization and export orientation of Indian agriculture.

Crop diversification methods like crop rotation, mixed cropping and double cropping have been found successful in many situations. The major advantages of these types of diversification include reduced erosion, improved soil fertility, increased yield, reduction in need for nitrogen fertilizer in the case of legumes, and reduced risk of crop failure. Diversity of crop varieties can enhance the stability of yield and result in water saving. Thus, genetic diversity and location specific varieties are essential for achieving sustainable production.

4.12 Management Issues

The previous sections have mainly dealt with issues relating to development of water resources. Equally or even more important is the aspect of efficient management of the developed resources so that wastages are minimised, available water is allocated according to the assigned priority of use and the environment is sustained or improved as a result of such management. Management should be such that it does not adversely affect the existing instream uses and the eco-system.

The first Green revolution was based on a radical transformation of the production function; from rainfed condition to irrigated condition linked with use of improved seeds and fertilisers. Second revolution in agriculture is required now, but the technology change of the first revolution is largely exhausted. The new revolution should, therefore, take up the management issues including linkages with the farmers, command area development, water conservation techniques, participatory irrigation management and institutional reforms. An institutional transformation is required and a holistic approach is called for inter-linking in a comprehensive manner, the approaches to address institutional, financial and technical constraints together for achieving the objective of reaching the full potential of irrigated agriculture. All reforms must be backed by research and diagnostic analysis for optimisation of results. India's exposure to global markets underscores such need in order to compete and play a significant role.

Further expansion of irrigation facilities now experiences increasing constraints due to environmental concerns and competing demand for water from other sectors. Therefore, there is need for a paradigm shift in emphasis towards improving the performance of existing irrigated agriculture. With problems of water logging cropping up, there is also need for reclamation of land for maintaining the sustainability of benefits. Marginal changes in irrigation practices will not have the desired impact. World Bank Irrigation Sector Review Report for India mentions that to achieve, for instance, four percent growth in irrigated agriculture, productivity per unit area for irrigation needs to be doubled by the year 2015. This can be done only if the efficiency of the existing systems is enhanced, water so saved is utilised to increase irrigation intensity and the farming practices are improved with modern inputs and technologies.

Irrigation consumes nearly 83 percent of water being used at present. It is estimated that even in the year 2050, it will continue to consume about 79 percent. It is, therefore, imperative that wastage and loss of water must be reduced to the minimum and optimal use of water made. Even 10 percent saving in irrigation water would increase the availability of water for domestic and industrial uses by about 40 percent in the long run. Efficient management of irrigation water, therefore, assumes great importance.

Irrigation management covers a large number of activities required to supply optimal quantity of water to the field to bring the crops to maturity, keeping in view reliability and timeliness of supplies. Water management, thus, not only includes intake, conveyance, regulation, measurement and application of water to farms for crop water use in appropriate quantities and at right time to increase production but it also includes timely and effective drainage (of excess water due to irrigation and rains) from crop fields to achieve, with the minimum costs, the above objectives over a long period of time.

The types of irrigation and drainage management constraints facing India are common to many **developing countries.** They largely relate to public sector managed surface irrigation systems and comprise numerous physical, institutional and financial/economic constraints.

The organisational constraints are dealt with in the Chapter - 8 on Legal and Institutional Framework and the financial constraints in Chapter 9 on Economic and Financial Management.

System Inadequacies and Phases of Irrigation Management

Inadequate maintenance has resulted in reduced efficiency of water use and inequalities in water distribution. From meagre funds allocated for maintenance, as much as 80 percent have to be spent on the staff leaving very little for physical upkeep and maintenance of the irrigation systems which have shown progressive deterioration. There are also many system inadequacies, such as:

- Inadequate capacity of the system for timely deliveries of water to the field. This is mainly due to structural deficiencies.
- Conjunctive use of ground and surface water is not encouraged through the mechanism of pricing and funding policies for ground water development within the command area.
- Inadequate infrastructure for quick communications and responses to effective water regulation and control.
- Inadequacy of water regulation and control structures causing waste and inequitable distribution, unreliable supplies and improperly planned water distribution, apathy of farmers, excessive seepage losses etc.
- Restraint to introduction of modern and innovative methods right from reservoir and water deliveries down to farm management, resulting in sub-optimal water management.

In physical terms, irrigation management can be subdivided into the following phases:

- Operation of the head regulator for supply of water either from the reservoir or from the barrage.
- Conveyance of water upto the field and
- Field irrigation and on-farm water management.

Operation of the Head Regulator for Supply of Water

For storage projects, an operational schedule is prepared which, inter alia, includes supply of water for irrigation on a fortnightly basis. During monsoon supplemental irrigation is necessary depending upon the rainfall. The schedule for rabi and hot-weather supplies is prepared at the end of the monsoon, say by October 15th, when water available for the year is known. For run-of-the-river projects, irrigation withdrawals are being made depending upon crop requirements and availability of water.

Conveyance of Water Upto the Field

Regarding conveyance of water to the field, there are several systems starting from inundation canals to sophisticated canal network having various degrees of regulation, control and automation. The following delivery systems are in vogue:

Sailab or Flood Irrigation System

The earliest settlements in India were on the banks of rivers like the Indus, Ganga and their tributaries where the flood plains along a river course were irrigated by sailab or inundation annually during the flood season and the flooded areas on both sides of the river not only received water for irrigation but also received rich and fertile deposits of the river silt.

In due course, small and large inundation canals were built which drew water from the river in spate (Old Fatehwadi project in Gujarat, Anicuts in Cauvery basin). The inundation canals draw water when the water levels in the river are high during floods.

Canal Systems

The planning and designs of the delivery systems have been continuously under transformation. The canal network was being constructed for the earlier projects to a block of about 150-200 ha on the presumption that farmers would provide water courses and field channels for irrigating their fields. In practice, this did not materialise and the lag in irrigation utilisation was increasing. Further, the control structures in the canal systems were not found adequate for regulation of the supplies to the command in accordance with the needs. Water measuring devices were not provided earlier, so also the escapes. With the passage of time, the need for providing lining for canal was recognised to save seepage losses in rocky and pervious terrains through which the canal systems were passing. Now a days such deficiencies are made good while planning new projects for which detailed planning and design criteria are laid down. The existing systems are also being modernised based on the revised planning and designs criteria. The distribution network is now being extended to outlets (chaks) serving approximately 40 ha areas with sub-chaks serving 5 to 8 ha area within.

Field channels are taken along the higher ground levels (ridges where feasible). They should, from hydraulic consideration, run along most direct lines to the fields to be served. However, the farmers object to this. Hence field channels may have to run along the field boundaries keeping in view that the length is minimum and the gravity command is not lost.

The delivery system and its operation have to be reviewed from time to time and modified, if necessary, depending on the actual field experience. For example, Kosi and Gandak canal systems have several deficiencies. Control structures are inadequate. Escapes cannot function because the drains are cultivated (unauthorisedly) and farmers do not permit the operational staff to let surplus water discharge into the existing drains.

The following planning and design features for the canal system of Sardar Sarovar Project are given as an example in which improvement over the past *practices has been attempted:*

- Lining of minor system down to smallest government channel to keep seepage losses to the minimum and conserve water;
- The lowest unit of operation is a chak of 40 ha approximately;

- Forming irrigation service units of a whole village [Village Service Area (VSA)] or a group of villages based on agronomic boundaries;
- Branches down to about 8.5 m^3/s capacity to be with upstream control with canal automation and down below manual control to meet full requirements of water;
- Introduction of rotational irrigation distribution system (on and off type), below 8.5 m^3/s capacity with water allowances considered regionally;
- Integration of ground water with surface water where feasible for conjunctive utilisation;
- Establishment of a reliable and foolproof voice communication system;
- Supplying water on volumetric basis - satisfactory measurement devices will be introduced at strategic points in the network.

Conveyance Systems- Difficult Areas

Hilly Regions

Traditional kuhl which is a natural gravity irrigation system is followed in hilly and mountainous regions. The water supply from kuhl is inadequate and inequitable most of the time and is surplus in some periods when farmers do not require water for irrigation. Due to poor water control and lack of water distribution system, the head reach farmers divert kuhl to their fields depriving the farmers located lower down of water. Some times, en-route storage tanks are created with LDPE film lining in the beds to tide over shortages. Such systems are followed in Himachal Pradesh and Kashmir.

Flat Terrains (Often Saline) and Coastal Areas.

These areas remain flooded during monsoon and sometime thereafter also. There are in general no drainage channels. The conventional canal network, if provided, would get damaged due to storm flooding. Further, because of flooding, there would not be any access for regulation and control. The areas generally become dry only in November - December when it would be too late to sow Rabi crops. In summer, these areas have salt incrustations on surface. Such areas are provided with irrigation water by excavation of parallel trenches about 6 to 8 ft. deep at regular intervals depending upon the permeability of the soils. Canal water is fed into ditches which also serve as drains and farmers lift water from the canal cum drains for irrigation. Thereafter, the water returns over the surface as well as through under ground flow back into the drains. Thus, the area remains dry and salts are moved by leaching. When the drainage water becomes poor in quality for reuse for irrigation, fresh water is added so that acceptable quality of water in the ditches is maintained for irrigation. The Bhal area of Gujarat is an example.

Field to Field Irrigation Systems

Under such systems as in Cauvery delta, the canals extend only upto large blocks of land to be irrigated (CCA) which are generally flat. Water is supplied from field to field to a mono crop, mostly paddy, which is grown in different seasons. This old system is being followed in other parts of India also. It is wasteful in use of water and does not permit diversification of crops which in turn leads to low productivity per unit quantity of water. Waterlogging and salinity also occur. Such systems are being modernised by providing control structures and extension of canal systems to serve smaller blocks of CCA to the extent feasible. This would also permit crop diversification.

Tank Irrigation

This is dealt with in Chapter-6 on Local Water Resources Development.

Field Irrigation and On-farm Water Management

There are various methods of application of water in the fields. The method of irrigation selected should conserve soil as well as water and prevent waste either through deep percolation or through surface overflows on the borders of the field. Field preparation and levelling assumes great importance for achieving high efficiency of water use. Irrigation water can be applied to the land in the following five general ways :

- by flooding, thus wetting all the land surface;
- by furrows, thus wetting only part of the ground surface;
- by surge flow in furrows, which reduces the infiltration of water and thus increases efficiency of water use;
- by sprinkler, in which the soil is wetted in much the same way as rain;
- by sub-irrigation, in which the surface is wetted little, if any, but the subsoil is saturated;
- by localised irrigation (drip irrigation), in which water is applied at each individual plant at a near daily rate.

For distribution of water within the field, various systems are used such as border irrigation, level-border and basin irrigation, contour levy irrigation, contour ditch irrigation, furrow irrigation, corrugation irrigation, sprinkler irrigation and drip irrigation.

4.13 Irrigation Water Distribution Systems

The principal requirement of a good irrigation water distribution system is that it involves minimum loss of water and ensures timely and equitable supply of water to all the irrigators in the command irrespective of the relative locations of their fields in the command. The system should involve minimum operational or interventional efforts on the part of the project management. Different states in the country have been following different systems of distributing irrigation water which have been evolved over the years in the light of availability of land and water resources and agro-climatic conditions. Some of the important systems in use in different states are the Warabandi /Osrabandi/ Shejpali, Block and Satta systems.

It is seen that most of these regional systems have some drawbacks and do not have country-wide applicability. They continue to be practised even now as the concerned projects had been planned and designed keeping such operational practices in view. Many of them cannot ensure equitable allocation and distribution of water to all the irrigators. New projects in the country are, therefore, being planned envisaging equity and timely distribution of water with minimum of outside intervention. The main elements of such distribution systems are the rotational water supply (RWS) by turn to various outlet commands through on-and-off operations, allocation of water to farmers in proportion of their land holdings, delivery to groups of farmers in bulk at the outlets by the farmers themselves. Participatory irrigation management (PIM) by farmers would ensure that each one of them would get his due share at the proper time and that the procedures would be simplified and would enable farmers to make mutual adjustments in distribution of water, if necessary. Wherever possible, even some of the existing irrigation projects are being modified to suit the introduction of RWS and PIM.

IRRIGATION WATER DISTRIBUTION SYSTEMS

Osrabandi is the synonym for warabandi. This system is practised in UP, Punjab, Haryana and Rajasthan. Under this system, water is supplied according to a predetermined schedule to each farm according to the turn. The supply of water is from tail upwards to ensure that the farms in the head reaches do no receive excessive waters resulting in unequal distribution. This system is considered to be the best to ensure equity, reliability and efficiency in water distribution. Punjab, Haryana and Western Uttar Pradesh have achieved high water use efficiency under warabandi system. Efforts are being made to introduce this system in other places.

Under Shejpali system, the farmer applies for water for a specific crop by a due date. On sanction of the application by the government Agency, water is supplied according to the requirement of crop by rotation. The schedule of supply is notified in advance. This system has been followed in parts of Maharashtra and Gujarat.

Block system largely followed in Maharashtra ensures long term guarantee of supply to the farmer for a period of 6 to 12 years as against supply limited to only one year or less in case of other systems. While sugarcane blocks are sanctioned for a period of six years, garden blocks largely for citrus fruit trees are sanctioned for a period of 12 years and two seasonal crops are sanctioned for a period of 6 to 12 years. This system has created islands of prosperity and also entails less efficient use of water in terms of production per unit quantity of water.

Satta system was largely followed in Bihar in Sone canal system. Under this system, long term agreements with groups of cultivators from a village are made. The group decides its leader, called Sattedar, who is responsible for internal distribution of water within the group and also for recovery of water charges. The system, however, did not work satisfactorily and has been given up.

4.14 Conjunctive Use of Surface and Ground Water

Conjunctive use connotes management of all water resources in an area including surface and ground water in harmonious manner such that the total water use in the area over a period of time is optimised. The quantification of water available for conjunctive use is decided by establishing a general ground water balance in the command area "with and without conjunctive use conditions". The planned quantity of ground water has to be adjusted in such a manner that neither progressive lowering or rising of water table occurs nor there is deterioration of quality. The main practices of conjunctive use of surface and ground waters have been discussed earlier. There are some examples of implementation of conjunctive use which highlight the need for such use (See Box).

CONJUNCTIVE USE OF SURFACE AND GROUND WATER

SAI Gomti Interfluve Tract – Part of Sarda Sahayak Irrigation Project – U.P

With the commissioning of Sarda Sahayak Canal System in June, 1974, higher water levels were observed and it was found that there was an increase in waterlogging condition and spread of salt ingested land (Usar) owing to capillary action. It was noticed that the existing availability and use of surface water in the upper and middle reaches of canals had given rise to significant seepage resulting in rise of ground water levels affecting agricultural productivity due to lack of well defined management strategies for optimal utilization of water resources.

Conjunctive use studies revealed that judicious utilisation of the surface and ground water would require construction of additional 21,375 tubewells for lowering the water table and increasing productivity.

Indira Gandhi Nahar Project Stage – I

With the introduction of irrigation, the water level was rising at an alarming rate of one metre per year, as a result of which the area came under waterlogging and salt salinity also increased ever year. Conjunctive use studies established that additional 10,023 shallow tubewells would help lower water table and increase the area under irrigation by 0.1 Mha.

Hindon-Kali Nadi Doab in Saharanpur & Muzaffarnagar in U.P

The conjunctive use study for optimising surface and ground water and maximising the agricultural production of the command reveals that 80 percent irrigation intensity is the most optimal. Achieving 100 percent intensity would create decline of 0.33 metre of groundwater level annually. Hence, it was suggested to reduce the water intensive sugarcane crop during the non-monsoon season.

Mahi-Kanada Canal Command (Gujarat)

The conjunctive use studies revealed that irrigation utilises 95 percent of the total available water resources with the cropping intensity of 179 percent. The surface and ground water contributions are 2,221 and 734 MCM respectively in the proportion of 65 : 35. Full utilisation of the available ground and surface water has taken place and this is considered to be most ideal situation of conjunctive use as per the studies.

4.15 Electricity Consumption in Agriculture

Electricity plays an important role in agriculture sector. It has been observed that agriculture remained at second place among the consumers of electricity after industry. Electricity consumption in agriculture has increased from 1,892 giga- watt hours (GWh) in 1965-66 to 85,736 GWh in 1995-96, thus registering an average annual growth rate of 13.6 percent against the growth rate of total consumption of electricity of 8.1 percent. The percentage of consumption in agriculture to total consumption has increased from seven percent in 1965-66 to 31 percent in 1995-96. During 1995-96, Maharashtra with consumption of 13,621 GWh of electricity for agriculture was at top followed by Andhra Pradesh, Gujarat, Uttar Pradesh and Madhya Pradesh having consumption of 11,575, 10,152, 9,888 and

8,235 GWh respectively. The percentages of consumption in agriculture to total consumption of electricity for above five states were 30, 50, 39, 37 and 36 respectively. Andhra Pradesh remained at top with half of electricity consumption in agriculture sector. Analysing the per capita consumption of electricity in agriculture in 1995-96, it is observed that amongst the states, Punjab with per capita consumption of 265 kilowatt hours (kWh) was at the top followed by Gujarat and Haryana having per capita consumption of 227 and 215 kWh respectively. The per capita consumption in agriculture at national level stood at 93 kWh. Punjab is also the leading state as far as per capita total electricity consumption is concerned followed by Gujarat, Goa and Maharashtra, in that order.

Irrigation pump sets energised as on 31.3.1995 were 10.7 million. Among the regions, southern region was on top with its share of 41 percent in total irrigation pump sets energised followed by western and northern regions with 33 percent and 22 percent respectively. Among the States, pump sets energised were highest in Maharashtra with 1.92 million pump sets followed by Andhra Pradesh, Tamil Nadu and Madhya Pradesh with 1.61, 1.49 and 1.40 million pump sets respectively. According to 1981 census, 85.3 percent of rural population had been covered by electricity. Among the regions, the southern region with 100 percent rural population coverage by electricity was followed by northern and western regions with 91.5 and 91.3 percent coverages respectively. Rural population of 18 States/UTs has been covered fully by electricity. In eastern region, Bihar is far behind with 36.8 percent coverage and similarly in north-eastern region, Arunachal Pradesh is lagging with 33.9 percent.

Heavy subsidies in electricity consumed for agriculture have tended to encourage wasteful use of energy and also wasteful use of water. This has also encouraged the farmers to overdraw water from deep aquifers thus causing water quality deterioration in many cases. The subsidies have also adversely affected the financial conditions of the State Electricity Boards. It is, therefore, necessary to gradually reduce the subsidy on power for agriculture.

4.16 Operation and Maintenance

Operation of the water delivery system calls for systematic studies of the cropping pattern in the command area including its trends in the command area and the crop water requirements. Equity, timeliness and efficiency in distribution of water are the three main attributes of successful operation. The operational strategy has to meet the fortnightly requirement of water throughout the crop season. The main canal, branches and distribution system, more or less, cater to the average requirements of water during the rotational period. However, the minors, sub minors, water courses and field channels cater to on and off requirements where distribution of water is by rotation of chaks. In such a system, the smaller channels carry proportionately higher discharge. Where continuous water is supplied to all channels down to the field, smaller channels also carry more or less uniform discharge. Due allowance is kept for seepage losses while determining the canal capacity. In number of systems where the night irrigation is not strictly resorted to, considerable wastage of water occurs. The operation of the system has to be designed duly considering the soil-water-plant and climate relationships.

In an ideal condition the quantity of water to be supplied to the crop should be just sufficient to meet its consumptive evapo-transpiration requirements at various stages of growth. Due to physical limitations involved in storing, conveying and applying the water in the field, much more water than actual requirement of the crop has to be released from the storage.

There is a general belief amongst the farmers that greater the depth of flooding in the field, the better it is for the crops. This may partly be due to the fear that next watering may be delayed. Irrigation operators have to convince the farmers that over-irrigation results in reduced production and may cause water logging and salinisation. In fact, if 'x' is the optimum quantity of water in terms of delta required for bringing the crop to maturity, reducing the supply to about 80 percent of 'x' will only result in a marginal loss of productivity but the balance 20 percent will bring correspondingly larger area into irrigation, thus contributing to sizeable overall production and at the same time, satisfying the irrigation needs of larger population besides reducing the risk of waterlogging.

The Commission recommends that irrigation operators should educate the farmers with pilot experiments and demonstration plots, regarding the advantages of less than optimal consumption of water.

Water Use Efficiency for Irrigation System

As water released from the storage has to entail several losses before it reaches the crop, its quantum has to be considerably in excess of the actual crop water requirement. The overall efficiency of a system is measured by the extent of water actually used by the crop out of the water released from the reservoir. This overall efficiency (E) is made up of partial system efficiencies which include (i) conveyance efficiency (Ec) which is the ratio of the volume of water delivered to the distribution system to the volume released from the storage (excluding water drawn from the system for non-irrigation uses, if any), (ii) distribution efficiency (Ed) which is the ratio of the volume of water delivered to the fields to the volume of water delivered at the head of the distribution system (excluding non-irrigation uses in the distribution system) and (iii) field application efficiency (Ea) which is the ratio of the actual volume of water required by the crop to the volume of water delivered to the field. The overall efficiency E can thus be expressed as

$$E = Ec \times Ed \times Ea$$

The overall efficiency can be high if the losses in the system can be minimised. The losses during conveyance and distribution occur because of seepage and evaporation, leakage from structures, evapotranspiration through weeds, pilferage of water, operation of escapes, non-use of water by irrigators during night resulting in wastage at tail etc. Losses in fields occur on account of inadequate land levelling and land shaping, deep percolation, overflow over field dykes, evaporation from the field and the differences in the water use efficiencies of different modes of application like border- strip, basin, furrow, flooding, field to field etc.

Steps like lining of the system, provision of adequate control structures, prevention of leakages and pilferage, rotational supplies with obligatory night irrigation, undertaking adequate CAD and OFD works and training of farmers for efficient water application practices can considerably improve the overall system efficiency.

Water Accounting

At specified definite locations of the canal and delivery systems complete records are kept of water withdrawn from the reservoir or the river system as well as the water which flows through the various branches, distributaries and other net work channels and at outlets as well as water flowing through escapes. Simultaneously, the records are kept of the crops and corresponding areas irrigated and depth of waterings applied.

In Maharashtra and Gujarat, daily accounts are kept by measuring the index AI/DC where AI denotes area irrigated and DC denotes day-cusec. In this system, the area includes mix of all crops but is measured separately for each minor and distributory. This index gives a comparative idea regarding the efficiency of water use and system capabilities and its performance. For the same area and crop mix, the efforts should be made to improve AI /DC.

Preparation of Plan of Operation and Maintenance (POM)

The plan of systematic operation and maintenance is a sine qua non for efficient management of irrigation. POM requires a dynamic view taking into consideration the trends, both past and future. The objectives of POM are:

- to achieve stipulated levels of project services including maintenance at minimum achievable cost; and optimum use of canal water,
- to provide detailed O&M guidelines during various anticipated scenarios of water availability, including equitable water distribution upto the tail end of the system,
- to effect efficient co-ordination of staff, equipment, physical and financial resources and related disciplines, active involvement of farmers etc.,and
- to establish guidelines to achieve the set objectives, treating all project facilities as integral parts of the project.

With the passage of time and changing cropping patterns, irrigation methods and techniques of POM require upgrading.

Generally, the operation of the system upto the government outlet (chak) level is being carried out by the irrigation management staff. The operation of the field channels for feeding the sub chak area is being done by the farmers. Inspite of total agreement amongst the State Governments (as resolved in various Conferences of Irrigation Ministers), the warabandi (rotational system) has not been introduced in many states with sufficient speed and dedication. There may be difficulties and constraints in introduction of warabandi but no efforts seem to have been made to overcome them by way of removing constraints. The Commission recommends that every State Government should make whole hearted efforts to introduce Warabandi system including night irrigation.

Role of Drainage in Operation

In several projects undertaken in recent years, the drainage component of the schemes had been deferred. While this had reduced the initial expenditure on the project, the drainage aspect was subsequently lost sight of during the operational stage till waterlogging and salinity were noticed. In many cases where drains have been provided, they are not being adequately maintained. They get silted up and are often used by farmers for dumping the waste materials. Often new developmental construction works in the command impede drainage. Maintenance and remodelling of existing drainage systems, therefore, is a high priority task. Ideally, comprehensive drainage master plan for the entire project should be prepared simultaneously with the canal network planning and the excavation of the drains should also be taken up alongwith the construction of the canals so that the soil from the drain excavation can be useful for canal banks and the drainage network becomes ready alongwith the canal system.

Role of Monitoring Waterlogging and Salinity in Operation

The operational staff is expected to monitor the quality and levels of ground water movements over a period of time. Soil chemistry should also be checked periodically to assess the salt levels. Where the water table is found to rise to an alarming level, steps must be initiated in advance to reduce input of water by restricting the water supply and by changing the cropping pattern as well as by conjunctive use of ground and surface water. Surface drains may also require to be deepened so as to provide drainage to the high water table. Leaching doses of water application may sometimes be required to wash and drain away salts in the soil.

Maintenance of Irrigation Systems

Maintenance can be broadly classified into three categories :

(i) preventive maintenance
(ii) operative maintenance
(iii) special repairs and disaster maintenance

The requirements of preventive maintenance for different components of the irrigation system are different. These operations can be systematically itemised and estimated with a fair degree of accuracy at the beginning of a fiscal year. The operative maintenance consists of surveillance and repairing the damages or defects as they are noticed. The third and most critical item of maintenance is the one relating to distress caused by more serious failures. These are really accidents which do occur once in a while inspite of the best of efforts on part of the maintenance staff. However, with timely and systematic preventive and operative maintenance, the frequency of such damages can be reduced and the extent of damage minimised. The rectification of damages caused by such disasters naturally takes the form of the execution of works of a capital nature. Such expenditure is generally classified as special repairs, to distinguish it from the ordinary repairs of the type undertaken under preventive and operative maintenance. Budgetary provisions for such expenditure can be made in accordance with the disaster management policy of the states.

Improving Operation and Maintenance

Experience indicates that inadequate budgetory provisions have very badly affected the O & M functions. The necessity of providing adequate funds has been discussed in detail elsewhere in the Commissions' Report. While there can be no two opinions about the necessity of making adequate budgetary provisions for O&M, it is equally important that working expenses are cut down to the minimum by streamlining and reducing staff expenses and overheads, adopting mechanised methods, resorting to modern communication and management information systems, improving infrastructural facilities and paying timely attention to necessary repairs to prevent further deterioration.

One important requirement is to increase the technical content in the O&M function. At present most of the operations and repair functions are being carried out at the level of unskilled or semi-skilled staff or low level supervisory personnel. In most cases they do not possess the knowledge about the requirement for efficient functioning of the various components of the system, the specifications for their construction and repairs and the know-how about the identification of physical or performance defects. As a result, the system rapidly deteriorates and also becomes inefficient. Substantial reduction of non-technical staff and suitable increase in the technically trained staff is one necessity. A more significant contribution must come from vigorous training of the O&M functionaries in respect of technical and functional requirements of various system components, their design and safety standards, observation and identification of their defects, correct methods of measurements of various parameters, functioning of various gauges and instruments, their observation and calibration, water accounting and budgetting etc. Several States have WALMIs and Staff Training Institutes. These have to be intensively geared up to train the staff in various activities.

In addition to the knowledge of engineering principles and requisites, the O&M staff should also have adequate knowledge about soils, their classification, water requirements of crops at various stages of growth, the agronomic inputs and practices, production statistics etc. Their friendly and continuing interaction with individual farmers and WUAs from time to time is also most essential.

Another vital input would be the improvement in the technologies and gadgets used in the system. Thus more reliable and accurate instruments and gauges should be installed. As far as possible, they should be automatic and the data transmission should be fast. Similarly, communication and reporting systems should be upgraded and infrastructure facilities improved. Beneficial use of local materials should be encouraged through appropriate field research, if necessary. Use of geotextiles, geomembranes, and other non-conventional construction materials can be introduced wherever they are cost effective.

In short, there is enormous scope for technology upgradation in operation and maintenance of irrigation systems. A modern and hi-tech O&M system can not only save the recurring costs but also contribute to the reduction in capital costs through significant conservation and efficient use of water and consequent lessening of the necessity of expanding irrigation through new projects.

4.17 Modernisation of Existing Irrigation Systems

The remodeling and modernisation of the existing systems has become imperative due to various reasons such as upgrading of planning and design standards, meeting the water requirements for hybrid crops at various stages of their growth, change in cropping patterns and improvements in operational methodologies etc. This programme was initiated in early 70s by various State Governments. Considerable headway has been made and some systems have been modernised even twice. Although, prima facie, the B.C. ratio of modernisation scheme should be higher than that for a new scheme, the figures of actual benefit cost ratios on completion of modernisation schemes are not available. Though the Ministry of Water Resources has taken up review of performance of a few modernised schemes during the last couple of years, performance reviews of modernisation schemes on completion are not available in most of the cases. As a result, it has not been possible to assess whether the enhanced benefits are commensurate with the costs incurred. The Commission, therefore, considers that after each modernisation project is completed, a performance review should be carried out which should assess the benefits and costs and arrive at benefit cost ratio and internal rate of return. Such a review should be carried out for all modernisation projects which have since been completed. For new projects to be taken up under this programme, following technologies and reforms should be included as components of the project:

- reassessment of culturable command area.
- review of cropping pattern in light of the irrigability classification of soils.
- review, on the basis of detailed soil surveys, of status regarding rise in ground water, waterlogging, salinisation etc.
- review of methods of operation of the canal - whether Warabandi, canal automation etc. and the improvement of existing control and regulation arrangements can meet the demand for augmentation of supplies.
- review of the canal capacities of the system and remodelling and strengthening of the system, where necessary.

- review of network below government outlet and strategies for on-farm development - whether PIM could be the feature of the system in near future.
- provision of efficient communication system
- provision of measuring devices and escapes
- review of organisational structure and preparation of O&M Manual and Management Information System.
- identification of the type of data to be collected for building the data base.
- need for drainage system where necessary including promotion of conjunctive use of ground and surface water.
- measures to reduce losses in conveyance down to the field - also improving the on-farm efficiency of water use.

It is estimated that about 21 Mha of irrigated area from major and medium projects from pre-independence period and those completed 25 years ago require to a great extent renovation/ upgradation / restoration of the areas which have gone out of irrigation, either partly or fully, due to deterioration in the performance of the systems. The total investment involved is estimated at Rs.20,000 - 30,000 crores over a period of 20 years. In recent times, the Water Resources Consolidation Project (WRCP) has been taken up in the States of Haryana (estimated cost - Rs.1,442.12 crore), Orissa (Rs.1,409.90 crore) and Tamil Nadu (Rs.807 crore) which also envisages, inter-alia, the completion of some non-completed major and medium irrigation projects and strengthening of institutions on the lines of Participatory Irrigation Management/Irrigation Management Transfer (PIM/IMT). Such projects are expected to be taken up in more States during the Ninth Plan period.

Remote Control and Canal Automation

Most of the canal systems in the country are presently operated through conventional systems by regulating the supplies of water through gated openings. Depending on the standing crops in a season under the command area of the system, water requirements are computed and the discharges in the canal system are fixed according to the requirements subject to availability of water. For measurements of discharge, devices such as standing wave flumes and gauge runs are established in the canal system. Depending on the discharges, gauge-discharge curves are prepared. The curves hold good when they are not affected by the back water effect of the down stream control device. Different types of modules are also used which supply water without being affected by the upstream or downstream levels. Various types of water delivery systems are in use in various parts of the country viz. warabandhi, shejpali, field to field irrigation, block system, satta etc.

Till recently, communication system within the command area was very rudimentary. Later on, VHF and telephone systems were adopted. Instant communication has now-a-days become absolutely essential for efficient control and regulation of supplies in the system and for reducing the avoidable wastage of water.

Canal automation is under implementation in India since the last one decade. In the field of canal automation, USA is the most advanced country. Many projects like California Aqueduct, Central Arizona Project, Coachella Valley Project and Salt River Project are being operated on automation concept in the USA. In France, control concept, popularly known as Dynamic Regulation, is implemented on Canal de

Province Project in southern France. In other countries, like Egypt, Morocco and Netherlands, remote monitoring with various control concepts has been implemented on irrigation projects.

In India also, there are six projects where either canal automation has been implemented or is being implemented.

Chambal Project in Madhya Pradesh is a multi-purpose project, a joint venture of the States of Madhya Pradesh and Rajasthan. Remote monitoring and control system is planned in 53 km long lower main canal having design discharge capacity of 53.8 cumecs in Madhya Pradesh and also on the branch canal systems, associated with the lower main canal.

Khadakwasla Project in Maharashtra comprises three dams viz. Tanaji Sagar Dam, Veer Palaskar Dam and Khadakwasla Dam. Remote monitoring and control system is planned in New Mutha Right Bank Canal (NRBMC) having design discharge capacity of 58 cumecs and its distribution systems. The automation also includes decision support system of the release of water in NRBMC from the reservoirs.

Majalgaon Project in Maharashtra supplies water to Majalgaon Right Bank Canal having 165 km. length and design discharge capacity of 83 cumecs. The water distribution to farmer's society is based on volumetric concept. Dynamic Regulation has been implemented on the Majalgaon Right Bank Canal (MRBC), Ganga Masala branch canal and its distribution systems. Use of duckbill weirs with hydraulically balanced gates has been implemented to maintain desired water level at the head of various distributories. On this completed project, water saving of about six to eight percent has been reported.

Rajasthan Agricultural and Drainage (RAJAD) project in Rajasthan, covering part of the Chambal command area, has implemented the real time information system for the irrigation management. The control system comprises local automatic control and/or local manual control.

Tungabhadra Project in Karnataka involves three canal systems running into a total length of 7,540 km and covering an irrigated area of more than 5 lakh hectares. Right Bank High Level Canal (RBHLC) of the project having design discharge capacity of 113.20 cumecs alongwith its distribution system has been covered under Supervisory Control and Data Acquisition (SCADA) system. As RBHLC also supplies water in Andhra Pradesh, maintaining required discharge and level at the State boundary is also a critical parameter being monitored.

Sardar Sarovar Project which is under construction is the first mega project in the country which has been planned and designed for canal automation. The canal systems have been designed and are being constructed to conform to operation on controlled volume for timely deliveries. A real time computer based monitoring system and a state of the art communication network will allow remote control operation of the canal conveyance system down to 8.5 cumecs design discharge capacity. Canal systems below 8.5 cumecs will be operated manually. The work of canal systems in initial reach covering about 4.0 lakh hectare area is on threshold of completion. A pilot project will be implemented in about 1.5 lakh hectares of irrigated area under advice of a competent and experienced consultant in this field, in near future.

The basic philosophy behind canal automation is the regulation and control of the supply into canal system according to day to day requirements, taking into consideration the actual precipitation that may occur during the crop season, soil moisture content, agro-climatic and other soil-crop parameters, so that the supplies of water are reduced to the minimum to bring the crop to maturity. Such planning has to be done within the frame work of reservoir operation planning for release of irrigation supplies. The system is based on placing sensors at various places to measure water depths in canal system, gate openings, soil moisture status, rainfall in the command area etc. and to collect the information on flows in canal network on real time basis. The information in real time is used to determine water requirements accurately with the following information which is collected at regular intervals:

(i) Type of crop(s) grown
(ii) Soil moisture status
(iii) Rainfall measured through rain gauges
(iv) Other meteorological parameters required for assessment of crop-water requirements.
(v) Flows in the canal system at each off-take point, and
(vi) Gate openings at each time stage.

With the values of the above parameters which are transmitted through telemetry and/or optic fibre cables, the computer works out the requirements of water on real time basis and issues commands for manipulation of gates by re-adjustment of its settings, so that the supply conforms to the desired pattern of distribution of water within the command area as assessed on real-time basis.

Automated operation of a canal system will yield many benefits. The important ones are as under :

- reliable water supply to farmers i.e. water arrives when it is needed.
- reduce restrictions on the capability of the farmers to attain high on farm irrigation efficiencies.
- ease of operation of canal system.
- reduction in water use (upto 6 to 8 percent).
- more accurate and equitable distribution of water.
- easier management of water systems.
- meet emergency situation effectively and in least time.

Where automation is proposed to be introduced in the existing canal systems, a complete review of the regulation and control structures including gates is essential. For accurate measurements, the gates have to be of radial type. Similarly, for operation of the gates, electronic, electrical and mechanical controls would be actuated by the computer commands. Necessary changes in the civil and mechanical components are, therefore, required to be incorporated. The concept of volumetric supply of water to the farmers has to be promoted and the WUAs educated to accept it.

In case of new projects, the automation has to be initiated right from the beginning down to branch canals and later on extended to the distributaries and further to the minor heads within the minor service area. WUAs can manage the distribution themselves in minor service areas and provide necessary information on day to day basis through communication system.

The cost of automation depends on the degree of automation desired. For a new project the cost may vary from 2 to 3 percent of the project cost. For an existing project, built-in-constraints limit the degree of automation and cost will depend on remodelling requirements and degree of automation.

Canal Automation is a new technology which is being introduced in some projects in our country as mentioned earlier. We do not have experience of its performance under the management practices adopted in our country. Therefore, performance requires to be watched carefully and the modifications, if any, identified to be incorporated in the future canal automation projects. The approach should, therefore, be somewhat cautious before large scale programmes are taken up.

4.18 Reuse Of Waste Water Including Saline Water

Storm water originating from the command area can be reused in two ways: (i) by diversion from the drains or direct lift therefrom and (ii) by filling of tanks from which the ground water also can be recharged.

Surface and subsurface drainage water, normally, is of a relatively degraded quality as compared to that of irrigation supply. Drainage water picks up during its travel, a variety of suspended and dissolved substances including organic and inorganic material, soil particles and salts. Its quality largely depends on the nature and amount of salts present in the soil profile and the salinity of underground water.

A drainage planner has to analyse drain water for nutrients, pesticides, and trace elements. The two major nutrients in drainage water are Nitrogen and Phosphorus, which contribute to eutrophication of surface water. Nitrogen can be in either organic form (ammonium) or the inorganic form (nitrate). Nitrate is the dominant form. Nitrite is the most harmful form, although it may be present in small quantities. Numerous agricultural pesticides also enter drainage water. High concentration of inorganic trace elements in irrigated soils and ground water pose a threat to the environment. Management of safe re-use and disposal requires an understanding of the characteristics of the drainage water and matching of those characteristics to the environmental protection needs of the re-use on disposal area.

Re-use is an important method of managing drainage water. There are following options for re-use of drainage water:

- Direct use for irrigation
- Blending with canal water
- Cyclic or rotational use
- Saline agriculture forestry system and solar evaporators
- Aquaculture, and
- Use of saline water

Direct Use for irrigation

In regions, where irrigation water supplies are limited, drainage water can be used to supplement it. However, the quality of drainage water determines which crops can be safely irrigated. Poor quality water is applied to crops with appropriate salt tolerance, after improvement in water management and ensuring adequate soil structure and permeability. In general, as the salinity level increases, both yield and quality of crop decrease. Guidelines for using saline and sodic water for irrigating crops are depicted in Table Nos.4.8 and 4.9 respectively given below. Table 4.8 indicates upper limits of salinity for different soil textures and in regions with different annual rainfall. However, it should be kept in mind that direct use of salty water may lead to soil salinisation, which can adversely affect the crops.

Table - 4.8

Guidelines for Using Saline Irrigation Waters [RSC<2.5 meq/l]

Soil texture (percent clay)	Crop tolerance	Upper limits of EC (ds/m) in rainfall regions		
		< 350 mm	350 – 550 mm	550 – 750 mm
Fine (> 30)	S ST T	1.0 1.5 2.0	1.0 2.0 3.0	1.3 3.0 4.5
Moderately fine (20-30)	S ST T	1.5 2.0 4.0	2.0 3.0 6.0	2.5 4.5 8.0
Moderately coarse (10-20)	S ST T	2.0 4.0 6.0	2.5 6.0 9.0	3.0 8.0 12.0
Coarse (<10)	S ST T	- 6.0 10.0	3.0 7.5 12.0	3.0 9.0 15.0

Note: ds/m = deci siemen / m = micromhos / cm S,ST and T denote Sensitive, Semi-tolerant and Tolerant crops to salinity of irrigation water respectively.

Table - 4.9

Guidelines for Using Sodic Irrigation Waters[RSC>2.5 meq/l]

Soil texture (percent clay)	Upper SAR (mmole/l)	Limits of RSC (meq/l)	Remarks
Fine (> 30)	10	2.5 - 3.5	(i) Limits pertain to kharif fallow rabi crop rotation when annual rainfall is 350 - 550 mm.
Moderately fine (20-30)	10	3.5 - 5.00	(ii) When the waters have Na 70percent (Ca+Mg > 25percent) or rainfall is > 550 mm, the upper limit of the RSC range becomes safe.
Moderately coarse (10-20)	15	5.0 - 7.5	(iii) For double cropping, RSC neutralisation is essential based on quantity of water used during the rabi season. Grow low water requiring crops during kharif i.e. Pearl-millet, Sorghum (grain) Okra, Guar and Sesamum, Avoid Rice.
Coarse (<10)	20	7.5 – 10.00	

Note: SAR = Sodium Adsorption Ratio
RSC = Residual Sodium Carbonate
Mmole/l = millimole per litre
meq /l = milli equivalent per litre

Source(for both the Tables 4.8 & 4.9): N.K. Tyagi-1996,"Salinity Management for Sustainable Agriculture - Future Proejctions", Proceedings of the Natinal Workdshop on reclamation of waterlogged, saline and alkaline lands and prevention thereof - sponsored by MOWR.

Therefore, for reuse of drainage water directly, management needs to be more intensive. Also, more precise methods for water application are needed. Drip irrigation can reuse saline water with advantage in more pervious soils. In drip irrigation, water is applied frequently, continuously leaching the wet bulb where most of the roots are concentrated. Sprinkler irrigation can cause leaf burn to some sensitive crops. This damage can be reduced to some extent by applying irrigation continually during the night and washing the salt off the leaves with non-saline water at the end of the irrigation cycle. The use of irrigation waters through drip system has revolutionised the production of some high value crops and orchards in countries like Israel and elsewhere specially when using saline waters. Drip system of irrigating crops has been observed to enhance the threshold limits of their salt tolerance by modifying the patterns of salt distribution and maintenance of constantly higher matric potentials. Other management techniques, which may offset yield loss, when saline water is used for crop production include (a) using more tolerant crop varieties, (b) using screens to separate seeds of larger size and weight, (c) increasing alternate furrow irrigation applying additional doses of fertilizers, (d) application of micro nutrients and (e) chemical amendments etc. (ICID-FAO 1997).

Blending with Canal Water

Blending comprises mixing of poor quality drainage water with good quality irrigation water and is the most economic and environmentally acceptable solution for re-use of drainage water. Studies at

CSSRI, Karnal using different blends of saline water with canal water indicated that this technique can be used successfully to irrigate winter crops.

Cyclic or Rotational Use

In cyclic or rotational use, canal and saline drainage waters are applied in a pre-decided sequence, either in alternate reuse or as per the crop growth stages. Many crops are more sensitive to saline water at the germination stage or initial establishment stage. In such cases, canal water is applied for pre-sowing/first irrigation and rest of the irrigations can be applied with saline drainage water. It is considered as a more useful mode than blending but may pose management difficulty.

Agriculture Forestry and Solar Evaporators

The concept of agriculture forestry system and solar evaporator is still at the development stage. In this technique, drainage water is used for irrigating certain tree species planted in blocks, instead of disposing it into evaporation ponds, river or ocean.

Also, about 80-85 percent of the initial volume of drainage water produced while growing salt sensitive crops, is sequentially re-used to produce salt tolerant crops, and the remaining 15-20 percent of drainage water, with increased concentration of salt, evaporates in solar evaporators. Drainage water can be used for wildlife or wetland habitat purposes also.

Aquaculture

The regenerated waters from major irrigation projects flow down to the coastal areas where the commands are bounded by the coastline or this accumulates at lower levels through drains. The regenerated water can be used for fisheries development including prawns. Ukai Project in Gujarat is an example where this is being done on an increasing scale.

Use of Saline Water

Saline water can be pumped from the saline aquifers and blended with fresh water for reuse. There are also certain tolerant crops where saline waters to a varying degree can be used.

4.19 Sewage Irrigation

The potential health hazards of treated reuse of waste water for domestic purposes are not fully assessed. Therefore, waste water should be mainly used for secondary domestic/municipal purposes such as flushing toilets, watering lawns, air conditioning and cooling etc. to minimise health risk. Only countries with a high level of technology for the operation and monitoring of advanced techniques of treatment of waste water systems can consider reusing water for domestic purposes. Preferably, the indirect reuse principle should be applied. For instance, using treated waste water for irrigation can be a very favourable proposition for releasing fresh water sources for domestic purposes. In fact, the nutrients present in treated waste water are an advantage for agricultural production. This is in fact being followed under a cooperative arrangement between Delhi Water Supply and UP and Haryana Irrigation Departments. Water supplied to Delhi by Haryana and UP is available for reuse in the irrigation system by UP and Haryana after suitable treatment. There are several examples of use of sewage and sullage water for irrigation in our country. These can be successfully adopted wherever feasible. In this connection, a policy on exchange of properly treated sewage for raw water needs to be drawn up and adopted.

There is need for a word of caution. The quality of industrial and municipal waste water requires to be constantly monitored, because such waters may have long term effects both on the crops and on health of the people.

II. Flood Control and Flood Management

4.20 The Himalayan rivers bring considerable quantities of silt and their basins are suffering drainage congestion and flooding. Similarly, deltas and estuaries of the west and east flowing rivers also suffer from floods. On an average, area affected by floods annually is about 7.52 Mha of which the crop area affected is 3.52 Mha. The floods have claimed on an average 1,515 lives and 95,285 heads of cattle every year during a span of 44 years from 1953 to 1996. Inspite of flood protection works such as flood embankments and reservoir operations, the problem of floods remains. With the growing population and increased developmental activity, the flood plains are being increasingly occupied resulting in more and more damages. Although it is feasible in most cases to provide certain degree of protection against flood in terms of reduced frequency and flood damages, there are no universal solutions which can provide complete protection against floods. The country has, therefore, to shift its strategy towards efficient management of flood plains, flood proofing including disaster preparedness and response planning and flood forecasting and warning and other nonstructural measures such as disaster relief, flood fighting including public health measures and flood insurance.

The need for flood management was felt in early fifties and the National Flood Management Programme was launched in 1954; the area provided with flood protection was then around 3 Mha. The total length of embankments was around 6,000 km. In the Policy Statement made in 1954, the objective set before the nation was to rid the country from the menace of floods by containing and managing floods. However, it was realised afterwards that absolute immunity from flood damage was not physically possible even in the distant future because of the unpredictability of several events which occur along with worsening situation by manmade activities. Hence, it was decided to provide reasonable protection that was found to be technically and economically justifiable and lay greater stress on flood forecasting, flood warning, flood fighting and flood management.

A number of National and State level committees were also set up from time to time upto 1976 when Rashtriya Barh Ayog (National Flood Commission) was constituted.

4.21 Rashtriya Barh Ayog (RBA)

Rashtriya Barh Ayog was constituted by the Government of India in July 1976 under the Chairmanship of Shri Jaysukhlal Hathi. Its main terms of reference were:

- to review and evaluate the flood protection measures undertaken since 1954 with special reference to the construction of embankments, and
- to evolve a comprehensive approach to the problem of floods as a part of optimum and multipurpose utilisation of water resources keeping in view the role of soil conservation and afforestation; suggest criteria for appraising flood protection schemes and mobilizing resources therefor; make recommendations on appropriate land use in flood plains, review maintenance of flood protection works and review the existing organisation and set up on flood control at the Centre and State levels and suggest improvements, where necessary.

The RBA made 204 recommendations. Some of the major recommendations were :

- Flood Plain Zoning and its management is necessary. Very few States have prepared Flood Plain Maps showing frequency and intensity of floods. Only Manipur has enacted Flood Plain Zoning Act. As a result, periodic displacement and rehabilitation of large number of people has become a common feature and huge amount by way of compensation is paid. Master Plan should be made for regulation of man-made activities in the Flood Plain Zones and if necessary, rehabilitation should be made on permanent basis with employment potential nearby.
- Unauthorised river bed cultivation needs to be prevented.
- For evaluating performance of existing and future Flood Control works, appropriate data base should be built up.
- Flood damage may be reported basin-wise separately for - Unprotected Areas; Protected areas; and Areas between embankments and rivers.
- Special flood prone area programme similar to drought prone area should be launched.
- National Council for mitigating disaster should be formed.
- Master Plan for flood control in a basin should form an integral part of Master Plan for optimum utilisation of land and water resources.
- Follow up on 25 important recommendations by Working Group for the Ninth Five Year Plan revealed that no concrete measures were taken to provide tangible physical achievements.

4.22 Recommendations of Task Forces

The Government of India in Ministry of Water Resources set up regional Task Forces in July, 1996 to review the impact of recommendations of the Rashtriya Barh Ayog, and to examine the flood management problems in the region and take an overview of the strategies evolved so far for mitigating flood problem and suggest short term and long term measures etc. The general Findings and Recommendations of the Task Forces are :

- State Governments should carry out realistic assessment of flood damages basinwise under categories - Unprotected areas; Protected areas due to failure of protection works; and Areas between embankments and rivers.
- Central Water Commission may expand and modernise flood forecasting systems.
- Encroachment by people in flood plains needs to be tackled effectively.
- Raised platform may be constructed in areas prone to frequent floods near villages.
- Adequacy of existing sluices, road and railway bridges, culverts and drainage channels should be examined.
- Construction of large flood moderation projects especially in North-East has been recommended.
- State Governments should get flood risk maps prepared and take appropriate measures.
- Enactment of Flood Plain Zoning Act should be pursued vigorously.
- Erosion problems should be considered neither in isolation nor on adhoc basis.
- Operation/rule curves of major reservoirs be reviewed and revised as necessary.
- States may consider all possible flood management measures before adopting them etc.

4.23 Overview of Flood Control Measures

Area liable to floods was assessed at 34 Mha (as shown in Annexure-4.1) when reasonable protection was already provided to 10.00 Mha at the time of RBA. The total of unprotected and protected areas flooded in any year constitutes area liable to floods which comes to 4.4 Mha. It is, however, known that during the years of high floods, at least some protected areas are also affected due to failure of some protection works. Assuming that around 4 Mha of such area is already accounted for in the 44 Mha area liable to floods, total area liable to floods would be around 40 Mha, that is, about one eighth the geographical area of the country. Fig.4.2 shows the area liable to floods in various parts of the country. It would be seen that the major concentration of the flood prone areas is in the Ganga-Brahmaputra-Meghna rivers system and in the coastal deltas of the Peninsular Rivers.

From 1954 to March, 1993, 16,199 km of new embankments and 32,003 km of drainage channels have been constructed. In addition, 906 town protection works have been completed and 4,721 villages raised above flood levels (see Annexure-4.2). Besides, storage reservoirs in general also have contributed to control of flood by way of reducing frequency/intensity of flood while the reservoirs with flood cushion have provided more effective flood protection. Flood cushion has been provided on the DVC reservoirs to provide flood protection to downstream area.

Assuming that the waterways of the rivers and drainage channels have not significantly altered, the area affected by floods in each year can be taken as the primary measure for estimation of flood damages. *Annexure 4.3 gives the annual figures of area and population affected, damage to houses and public utilities, loss of human life and cattle lost. Total damages are also indicated in this Annexure.*

The area affected has been fluctuating depending upon the natural rainfall intensities in various basins. There is no trend either increasing or decreasing. However, the figures reported for the population affected show a definite trend towards increase. The figures were 1.5 to 3 times the figures of area affected upto 1968. These increased to 4 to 6 times the area affected till 1984. Thereafter, the same increased to 4 to 8 times. Similarly, the damages to crops have also shown substantial increase in value compared to the area of crops damaged. Similar trend is noticed not so much in the number of houses affected but in the value of houses damaged. The human lives lost have not shown any perceptible trend. Noticeable increase, however, is found in damages to public buildings. The increasing trend may be partly due to increase in the value of the property or crops lost and partly due to over assessment in order to put a claim to larger assistance.

FIG 4.2 : FLOOD PRONE AREAS

Source : Central Water Commission

There has been considerable step up in government spending on flood management programme over the years (Annexure-4.4). It has gone up from Rs.14 crores during First Plan to Rs.942 crores during Seventh Plan. The Eighth plan (1992-97) outlay for flood management was to the tune of Rs.1,916 crores. The anticipated expenditure during the Eighth Plan on flood control works alone would be about Rs. 1,700 crores. The Central assistance on flood control works has risen sharply from Rs. 4.7 crores in Fourth Plan to Rs. 161 crores during Seventh Plan and it is anticipated to be about Rs. 250 crores against the target of Rs. 282 crores in Eighth Plan. At constant prices (1980-81 = 100), the total expenditure has gone up from Rs. 81 crores during First Plan to Rs. 702 crores during the Sixth Plan and Rs. 598 crores in the Seventh plan. In fact, the expenditure in the years 1992-93 onward has been of the order of Rs. 100 crores (at constant price) or more. Following such spending on flood management programmes, the area protected has risen from one Mha to 14.4 Mha at the end of 1992-93. Haryana's achievement by way of protecting 1.73 Mha of its total flood prone area of 2.35 Mha is noteworthy. Area benefitted due to flood management work is highest in Punjab (2.68 Mha) against 3.70 Mha flood prone area reported in the State. Other States where the flood management programmes have resulted in significant benefits (over one Mha benefitted out of flood prone area as reported by the States (1953-93)) are Andhra Pradesh (1.0 out of 1.4 Mha), Assam (1.7 out of 3.15 Mha), Uttar Pradesh (1.53 out of 7.34 Mha), Bihar (1.89 out of 4.26 Mha) and West Bengal (2.1 out of 2.65 Mha) though a large part of flood prone area in Uttar Pradesh still needs to be covered. The progress in the remaining States was either tardy or the problem was not as serious in terms of the area likely to be exposed to floods.

The National Water Policy suggested the following strategy for flood control and flood management :

"There should be Master Plan for flood control and management for each flood prone basin.

Sound watershed management through extensive soil conservation, catchment area treatment, preservation of forests and increasing the forest area and the construction of check dams, should be promoted to reduce the intensity of floods.

Adequate flood cushion should be provided in storage projects wherever feasible, to facilitate better flood management.

An extensive network for flood forecasting should be established for timely warning to the settlements in flood plains, along with the regulation of settlements and economic activity in the flood plain zones, to minimise the loss of life and property on account of floods.

While physical flood protection works like embankments and dykes will continue to be necessary, the emphasis should be on non-structural measures for the minimisation of losses, such as flood plain zoning, so as to reduce the recurring expenditure on flood relief".

4.24 High Priority Areas of Flood Management

Floods have been occurring frequently causing devastating damages to life and property. More attention is given to flood relief measures rather than to flood control and disaster management. Many important recommendations have been made from time to time but these are not followed up inspite of occurrence of repeated flood damages. A permanent machinery, therefore, needs to be set up for preparing a comprehensive plan of action for (a) Flood management, (b) Flood forecasting and flood warning, (c) Flood routing over the reservoir and (d) Taking structural and non-structural measures for flood control.

The following are the important action points :

Flood Plain Zoning and Legislation

Need for suitable legislation for flood plain zoning was stressed in the Conference of Irrigation and Power Ministers in 1972 and Draft Bill on Flood Plain Zoning was circulated in July, 1975. Thereafter, a Model Bill was also circulated by the Central Water Commission which provided for zoning of flood plains. However, only Manipur State has enacted the bill so far. It is time that the State Governments be impressed upon to carry out necessary surveys for flood plain zoning and that they classify the flood prone areas into different categories depending upon the intensity and frequency of the floods. The bill should provide for regulation of various activities and strategies for optimum use of the flood plains. No doubt, several States have undertaken survey but the work has not progressed much. Large scale contour plans indicating flood zoning are still to be prepared. The Commission recommends that the State Governments urgently undertake a time bound programme of preparing maps indicating zones in the flood plains after carrying out surveys and studies of past flood levels and lay down policy to regulate the land use in different zones. The following guidelines may be of use :

Priority -1 :

The buildings for Defence installations, water supply, telephone exchanges, aerodromes, railway stations and commercial centres etc. should be located such that they are above 1 in 100 year floods or maximum observed flood level.

Priority -2 :

Public buildings like Institutions, Government offices, Universities, Public Libraries and residential areas should be located above 1 : 25 year flood zone.

Normally, after each flood, the displaced families move back to the original site. This requires control and monitoring. Under appropriate flood zoning, higher areas with less frequency of flood should be earmarked for temporary habitation until families are finally rehabilitated on long term basis and raised platforms may be provided for shelter during high floods. Some shelter homes have been constructed in the State of West Bengal which rest on wooden ballies and pillars. The people can be sheltered in such homes and cattle kept below. Such ground areas are used as schools in non-monsoon period.

Flood Proofing

Flood proofing is essentially a combination of structural measures and emergency action plan not involving evacuation. Under this programme, providing raised platforms, relocating civil and public utility installations above flood levels and relieving flood congestion by appropriate operation of sluice gates, pumping etc. where necessary constitute the main activities.

Following thrust areas are suggested:

- Quick drainage facilities
- Potable drinking water, sanitary arrangements and education
- Human dwellings and animal shelters
- Raised platforms for shelter
- Storage facilities for food and fodder and other essential commodities
- Communication telelinks - Telephones/Wireless sets/roads/railway

Flood Insurance

Flood insurance would have several advantages of distribution of the load of flood damages over larger population. However, flood insurance has not been adopted widely in India though flood risk has been included in the 'cover' containing risks by the general insurance companies in India. It is popular in urban areas and big towns for protection against losses to the buildings. Due to practical difficulties of assessment of losses, crops are, generally, not included in the insurance cover.

Disaster Management and Preparedness

As regards damages to property and loss of life, flood disaster ranks number one according to the study carried out by United Nations in its publication " Guidelines for Flood Loss Prevention and Management in Developing Countries". All countries including developing countries have been afflicted by disaster floods. Disastrous floods are also caused by dam break (Kaddam Dam, Khadakwasla Dam, Kodaganar Dam, Machhu-II dam in India). Disaster preparedness plans have to be prepared for normal floods (with or without moderation from the upstream reservoir and for emergency situation such as dam break).

Disaster preparedness is aimed at minimising the loss of life and property by the advance warning and alerting the flood fighting and flood protection machinery to be mobilised at short notice in accordance with the strategies and plans prepared. These plans are formulated for disaster mitigation, warning, emergency operations, rehabilitation and recovery and involve training, post disaster evaluation, review and co-ordination at Central, State and local levels. Such plans need to be reviewed after each major flood and revised to meet the future eventualities more effectively.

The Ministry of Agriculture have brought out a `Model Action Plan' on the subject and circulated it to the States and Union Territories. On the recommendation of Group on Disaster Management, a National Disaster Management Institute has already been set up under the Ministry of Agriculture.

The State Governments look after the Disaster Management programmes. At the Central level, Flood Forecasting and Flood Warning Programme was commenced in the country in 1958 by starting forecasts of river Yamuna. Now, this system is vastly covered almost in all large river systems and is capable for issuing flood forecasts at 157 stations of which 132 are for water stage forecasts and 25 for inflow forecasts used for optimum operations of certain major reservoirs. For improving the quality of forecasts, modernisation of existing network has been taken up with external aid (UNDP, Denmark etc.). Forecasts are also arranged with the co-operation of the neighbouring countries such as Nepal and Bhutan.

There is, however, need for modernising flood forecasts and flood warning, both for flood routing through reservoirs as well as for minimising the loss of life and properties by strengthening the existing network and introducing telemetry, satellite communication and use of computers so that with appropriate software programmes, the incoming floods can be simulated on a real time basis. CWC is looking after such simulation for Narmada and for Tapi.

Disaster Preparedness Plans generally contain six basic elements, namely:

- Identification of emergency
- Undertaking preventive actions
- Notification
- Coordination
- Hazard area delineation
- Evacuation and termination with follow-up action

The elected representatives of the people like Members of Parliament, Legislative Assemblies and local governments and other responsible persons should be involved in Disaster Preparedness Plan. Assistance of voluntary agencies may also be utilised. For allocating responsibilities and familiarising them with the likely dangers, vulnerable areas and benefits of the cooperation, these should be discussed and decided in a joint meeting at Collector's level.

Flood embankments have been constructed extensively in various States to protect areas in the flood zones from recurring floods and are designed to withstand certain frequency floods. However, when flood higher than the design flood occurs, the flood embankment gets over topped and fails. Of course, such events occur rarely. Breaching sections are provided within the embankments so that in case floods higher than the designed floods occur, the embankment fails at a breaching section and extensive damage to the embankments and the land and property behind is avoided. The embankments also get breached due to improper maintenance and sometimes due to manmade breaches. The design and maintenance of embankments, therefore, call for special attention.

People's Participation

People's participation at all stages of undertaking flood protection and disaster management measures including relief and rehabilitation measures is essential. People at large have risen to such calamities and provided willing co-operation in relief and rehabilitation measures. What is required is to channelise this sentiment and create institutional arrangement for systematic and timely use of the people's participation capability. In construction stage, digging of drainage channels, soil conservation works, afforestation, water shed development etc. would greatly benefit from the involvement of local people.

Central Assistance

There is a tendency to over-estimate the flood damages in order to get more central assistance. The compulsion of prompt release of central assistance in a calamity like floods, does not leave much time to carry out the systematic assessment of flood damages. The Commission recommends that a permanent unit should be set up by each usually flood-affected state which can prepare maps and reports of flood affected areas for each flood event mentioning the flood levels reached at various critical locations and nature and quantum of damages assessed both in physical and financial terms. This unit can then check up with the help of satellite imageries and previous data, whether the assessment in the future floods (when they occur) needs to be scaled down or not. Such an assessment and reporting will not only help in planning the future protection works but also in the disaster management apart from ensuring realistic damage assessment arising out of various flood events in future.

There is also need for assigning responsibility to a Department in the State, which should review major development activities such as planning of roads, railways, barrages and urban development to ensure that these plans do not create major drainage problems and call for ameliorative measures.

4.25 Coastal Erosion Protection

India has a coastal line of about 5,700 km encompassing nine States and one Union Territory. Practically the entire coastline is affected by erosion in varying magnitudes. The reason is mainly caused by rise in sea level, waves and tidal attack, monsoon vagaries, human interference such as construction of wharf, fishing harbour, groynes, damming of rivers reducing adequate supply of sand etc. Mining in coastal areas also induces erosion problems. Measures to control erosion include non-structural and structural or the combination or both. Non-structural measures are artificial nourishment of beaches and vegetation cover such as mangrove plantation and Nipa palm.

The structural measures generally are sea walls, revetment off-shore break water groynes. Sea wall is more popular. Construction of sea wall has been taken up on a large scale in the State of Kerala where around 348 km was already constructed upto March, 1996. In Karnataka, about 30 km was constructed upto March, 1997. Marine drive in Mumbai was developed after construction of sea wall.

The Government of India has constituted a Beach Erosion Board for laying down general design principles and construction techniques and review performance of coastal erosion works etc. and render technical advice to specific problems at the request of State Governments. The Beach Erosion Board constituted in 1995 has since been reconstituted and renamed as " Coastal Protection and Development Advisory Committee". The main functions, interalia, include preparation of short term and long term plans for coastal protection, monitoring of works and review of action plans for rehabilitation and resettlement of the affected people.

In order to regulate and control the use of coastal land, CWC has circulated a Draft Bill amongst the maritime States which aims at constituting Coastal Land Management Authority under the umbrella of Central Protection & Development Advisory Committee. The member States were requested specifically to set up State Level Committees pending enactment of the Bill. West Bengal and Karnataka have formed such Committees. Further follow up action in this regard would help in proper regulation of the use of coastal land in harmony with the environment as well as avoidance of risk of coastal erosion.

4.26 Important Issues Concerning Flood Control and Flood Protection

Many issues concerning flood control and flood protection are being raised regarding the impact of the flood protection measures such as embankments, dams and reservoirs. These are discussed below:

Efficacy of Embankments

The question is often raised regarding efficacy and need for embankments. It is argued that the benefit of deposition of silt which serves as a fertiliser on the low lying banks is lost and if the embankment breaches, the damage is much more severe.

Embankments have created drainage congestion in the protected areas and are subjected to erosion by attacks from the river flows. After construction, silt laden waters do not enter the flood plains and to that extent, the natural silt deposits which have been contributing to the fertility of the land are not available after construction of the embankments. Further, the embankments give protection from floods up to the specified frequency of say 1 : 25 years or 1 : 100 years. If higher floods come, the embankments are over-topped and they are breached causing serious flood damages. Adding to the problem, building activity takes place behind the embankment in the false hope that the protected area is safe. On the plus side, inspite of the deficiencies mentioned above, the demand for providing flood embankments has been on the increase and since the areas behind the embankments are protected from frequent flooding, they are available for cultivation during monsoon as well as rabi seasons. Embankments also protect built up areas in towns and cities. However, care has to be taken to ensure that building of embankments in one river reach, does not cause damages in the adjoining and lower reaches.

If a broad review is taken on the performance of embankments, it must be admitted that 16,199 km of embankments constructed between 1954 & 1997, have provided effective protection of large area of nearly 17 Mha out of 40 Mha of flood-prone area. The loss of standing crops by recurring floods, however, far outweighs the benefits of deposited silt serving as fertiliser. Secondly, uncontrolled unembanked rivers tend to meander in larger flood plains width inducing erosion problems and shifting tendency. Admittedly, the embankments have certain negative environmental impacts such as non-deposition of silt in the otherwise flooded areas, loss of valley storages and consequent increase in the level of waters within the embankments and high damages in case embankments breach due to extraordinary high floods. Over a period of time, however, norms have been prescribed for determination of design floods for embankments in rural and urban areas and regarding provision of breaching sections at appropriate locations etc.

River Kosi has shifted about 110 km from east to west from the beginning of the 18th century. In this process, the river swept over an area of 13,000 sq.km in India and 1,000 km^2 in Nepal depositing sand and silt. The spacing between the embankments varies from 5 to 6 km. Inspite of wide spacing, the banks are on attack from time to time. The embankments have been largely succeeded in jacketting the river and the areas outside the embankment have been largely protected from the floods, except for occasional breaches, but there is a fairly serious problem of drainage congestion. Within the embankments sediment has been deposited but the levels of the deepest channel have remained almost unaltered.

The Commission recommends that performance review of selected embankments may be carried out and based on the findings, the planning, design and management of embankments may be reviewed for obtaining better results. It is essential to associate the beneficiaries in the upkeep and surveillance of the embankments during the monsoon season for prevention of possible breaching.

The impact of sediment transport through embanked channels has not been given adequate attention. This subject is very complex. The data regarding the quantum and quality of silt for different discharges should be collected and analysed for ensuring that the embanked channel has adequate capacity to transport the silt load. Bed levels also need monitoring to ascertain whether there is silting or scouring. The subject requires further research for which adequate observed database needs to be setup. The problem of sediment transport would get considerably eased after the total watershed development takes place in the upper catchments.

Effectiveness of Dams and Reservoirs

Most of the dams have no storage (flood cushion) reserved for absorption of floods, while a few storage dams have flood cushion reserved for absorption of floods. The latter type have a better capability to provide flood control. Even the former can provide flood control with appropriate flood forecasting system combined with advance releases. In an earlier paragraph, the performance of DVC reservoirs for reducing the flood peak was illustrated. DVC is a multipurpose reservoir system. While it provides flood protection, the main objective is to generate power. There is definite impact of dams in providing flood protection. The storage behind the dam absorbs the floods and reduces the frequency of flood occurrence.

Dams also absorb silt, especially medium and coarse variety and as a result, the waters released carry less silt. This has impact on erosion and deepening of the downstream reaches. This helps in improving the morphological behaviour of the river in as much as the flood levels and the meandering of the river course are kept under control.

There has been encroachment in the flood space downstream of DVC reservoirs under the false hope that they are completely safe due to construction of dam. Due to unplanned/unauthorised developments in such areas, the damage becomes more pronounced because of restricted capacity of the river channel to carry floods. It is, therefore, desirable to keep strict control on such unauthorised construction/development. Secondly, sand mining also induces erosion which needs to be discouraged. For boundary rivers, the construction of embankment on one side of the river may cause erosion on other bank causing inter- state disputes. Construction of embankments along the Yamuna and the Ganga is an example. As stated by us elsewhere in the report, there must be a regular established mechanism in each such basin to discuss & sort out the issues to the mutual satisfaction of the concerned states.

The problem, however, arises and an impression gets created that adequate flood protection is not given by dams. The reasons are completely different. Manmade activities such as encroachment of flood-zones largely on the banks and sometimes even in the main river channel over a period results in very heavy damage when high floods arrive infrequently such as once in 10 years or once in 25 years. Example of Surat city may be cited here. In the design of the dam, a safe release of 8.5 lakh cusecs was considered for preventing flood damage to the riverine areas and city of Surat along with flood embankments. However, due to encroachment or flood zones and construction of barrage bridges etc., the river carrying capacity has been affected. It may also happen that the reservoir may be located considerably upstream of the flood prone area and there may be synchronising of rainfall in the catchment area between the dam and flood prone area. In such a case, the impact of flood moderation naturally gets reduced.

Dams and Flood Moderation

Flood Moderation in DVC : Four dams were constructed in Damodar Valley Corporation Systems. Flood moderation was envisaged using the flood cushion provided in these reservoirs. It is estimated by the DVC authorities that a flood of 33,414 cumecs would have been experienced below Durgapur, had there been no dams, thus surpassing the design flood of 28,316 cumecs. However, D.V.C. reservoirs provided substantial relief from floods as seen from the Table below.

Regulation of 1978 Flood

Location	With DVC Dams		Without DVC Dams	
	3-hourly peak inflow (cumec)	3-hourly peak outflow (cumec)	3-hourly peak inflow (cumec)	3-hourly peak outflow (cumec)
At Maithon and Panchet	21,917	4,615	26,958	26,958
At Durgapur	10,732	10,732	33,414	33,414

The benefits in terms of avoidable flood damages have been much more considering the gradually reduced carrying capacity of the river Damodar in view of the encroachment of flood plains by buildings and habitation, especially by industries and public utilities.

Ukai Flood Moderation : Ukai reservoir is the terminal reservoir on the river Tapi in Gujarat. Devastating floods of 1959 and subsequent damages to the riverine villages and the city of Surat underscored the need for Ukai reservoir to moderate the floods. Ukai multipurpose project envisaging irrigation, hydropower and flood control benefits was sanctioned soon thereafter. Ukai multipurpose reservoir provides a live storage of 7,092 Mm^3 (5.75 maft) and flood cushion of 1,332.25 Mm^3 (1.08 maft). The dam was built in early seventies. It was planned that the maximum project flood of 0.495 lakh cumecs (17.5 lakh cusecs) could be moderated to 0.24 lac cumecs (8.5 lakh cusecs) by utilizing the flood cushion and resorting to advance releases after establishing suitable flood forecasting and warning system. While Ukai reservoir has provided considerable relief from floods by way of reduced frequency and moderation, the areas downstream, especially the urban areas of the city of Surat, have developed without adequate regulation and control. As a result, when 1998 flood came, huge damages occurred even with a peak incoming flood of 0.26 cumecs (9.25 lakh cusecs) in Ukai reservoir.

Earlier figure of safe flood for Surat viz. 0.24 lac cumecs (8.5 lakh cusecs) now requires to be lowered due to reduced flood carrying capacity of Tapi river in Surat city area. A total review of flood plain encroachments, afflux causing structures and flood embankments (partially built) is now necessary for evolving an appropriate flood forecasting and warning system (which needs to be strengthened and modernised for computer simulation of incoming floods) and reviewing of design flood embankment and sluice gates for protection of the city of Surat. Creating mock floods periodically is also being considered.

Multipurpose dams provide benefits of irrigation, hydropower, flood control etc. There is conflict of water use for various benefits. The rule curves, therefore, are being established for regulation of the flow during monsoon season and the reservoir is not allowed to rise beyond a particular level during different periods of monsoon for achieving the benefits of flood control by keeping the reservoir level low enough to absorb the coming floods. At the same time, care is taken not to depress the water levels very low so as to lose the benefits of irrigation and hydropower as per project planning. While such an approach is very logical and rational, lapses have been noticed in the operation of reservoirs which have resulted in loss of water or creating higher intensity of floods. The main reason is the lack of scientific database; non-use of modern technology for automated measurement of gauge levels, rainfall etc. in the upper catchments and their transmission through satellite or telemetry to a control station where the river flows are simulated for formulation of the most appropriate scheme for flood routing. Field engineers in-charge of reservoir operations should have a thorough knowledge and understanding of the hydrology so that the computer results are properly interpreted and validated by manual checks and the gates correctly operated and timely warnings given. Past results would also provide guide. There is also need to continuously update flood routing procedures keeping in view the encroachment in the flood zones lower down and consequently reduced capacity of the river channel to carry the floods. Flood zoning and enforcement of control measures are essential; otherwise, catastrophic damages can occur if a design flood or a maximum probable flood occurs.

Mock Floods

When high peaks of flood occur after a lapse of 10 to 25 years or more, areas protected due to reservoir operation are encroached upon by building and other activities. Creation of artificial flood is possible only in case of reservoir. In good years, when the availability *of water exceeds the* planned uses, waters can be released to create a flood wave in a controlled manner. This would enable the flood plains to remain more or less free from encroachment. Such artificial creation of flood is not possible everywhere but where feasible, these mock floods should have a full environment of a real flood by giving flood warning, keeping flood fighting machinery ready alongwith other protective strategy for protection of embankments etc. Therefore, they should serve as a drill to combat the real floods without adverse impact, when they arrive.

Valley Storages

Natural depressions and tanks as well as the natural and artificial drains are filled up or encroached upon for various development purposes such as agriculture and urban/sub-urban developments. This has accentuated the flood peaks and caused inundation over large areas which remain flooded for long periods affecting agriculture and public health. Mahi command area in Gujarat is an example. Appropriate legislation needs to be enacted to prevent blocking or encroachment of drains and filling of depressions and tanks.

Institutional Mechanisms

At the central level, the work of flood warning, flood forecasting, flood programming and flood management is being looked after by the Central Water Commission. This arrangement has been effective in issuing timely forecasts/warnings of impending rise in water levels/ discharges. The network needs to be extended to remaining flood prone areas. For the Ganga sub basin, the Ganga Flood Control Commission is an appropriate institution to monitor the schemes and give necessary advice. Similarly, in the Brahmaputra sub basin, Brahmaputra Board monitors the schemes and gives advice for planning of flood protection works. This system has proved to be of great benefit and giving timely warnings especially for inter-State river basins and has prevented large potential damages to both life and property.

III. Hydropower

4.27 River valley projects are an important element of optimum and integrated - water resource development planning. Large multipurpose storages provide benefits of irrigation, hydropower, flood control and water supply. The cost of dams is allocated amongst different uses, thus reducing the cost of each benefit. Hydropower, therefore, contributes not only to the larger availability of water but also to the reduction in the cost of benefits. In some cases hydropower competes with other uses such as irrigation or water supply, while in others it becomes a by-product of other priority uses. An overview of hydropower including the future scenario is, therefore, necessary in the context of long term and sustainable availability of water for meeting the future demand.

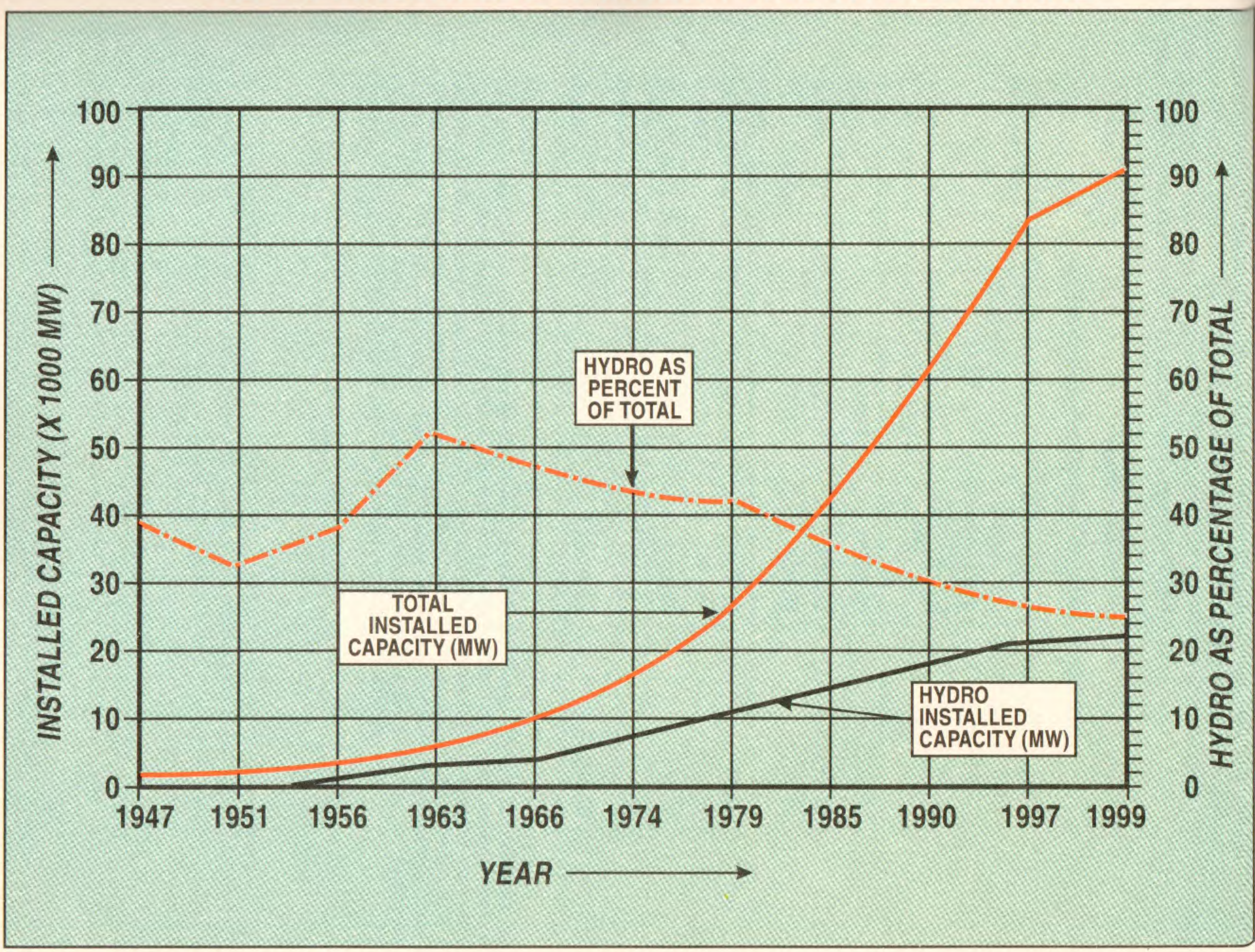
Water is also a source of energy. Water generates electricity when it is allowed to fall to a lower level through turbines and after power generation, water can again be used for other beneficial uses. The hydro-electric projects which have inherent ability for quick starting and stopping and almost instantaneous load acceptance and rejection, are ideally suited for meeting the peak hour demand and for enhancing system reliability in the most economic manner. The operation of hydro power projects is environment friendly and does not pose adverse impact unlike the thermal projects which have the associated problems of emissions and solid waste disposal. The hydro power projects have longer useful life spans. The hydro-electric projects are generally located in remote hilly and inaccessible areas and implementation of hydro power projects enables accrual of incidental benefits of development of road/rail communications, electrification, industrialisation and improvement of the quality of life in the backward areas. Contrary-wise there are also adverse effects on forests and environment and on human beings in the form of displacement of people. Hydro power is the cheapest in the long run amongst the various sources of power supply. It has no fuel cost and is thus almost free from operating cost escalations. It is renewable in nature and promotes conservation of non-renewable fossil fuels. For an efficient and optimal operation of a power system, an optimal hydro/thermal mix (40:60) is considered necessary. However, of late the proportion of hydro power is going down (see Fig. 4.3). The present hydro/thermal mix of about 25:75 calls for increase in hydro power capacity. The operation of thermal plants at a very low load (during off-peak period) would adversely affect the efficiency of the system, the plant life and fuel consumption. Installation of hydro power plants will help in improving operational reliability, stability of the power system and also in optimising the operational economy and meeting the peak load requirements.

Notwithstanding the availability of vast potential in India and many beneficial aspects, the pace of hydro power development has been slow due to a number of reasons such as delays in project formulation, need to preserve the pristine ecology of certain regions in the interests of the larger environmental considerations, such as, biodiversity; rehabilitation and resettlement problems of affected people and the inherent delays in the construction of hydro power projects.

4.28 Potential and Status of Development

The first systematic and comprehensive study to assess the hydro-electric resources in the country was undertaken during the period 1953-1959 by the Power Wing of the erstwhile CW&PC. These studies placed the economic hydro power potential at 42,100 MW at 60 percent load factor (corresponding to an annual energy generation of 221 billion units). The re-assessment studies of hydro-electric potential of the country, completed by Central Electricity Authority in 1987, assessed the

FIG 4.3 : INSTALLED CAPACITY AND HYDRO SHARE



Source : CEA

hydro power potential as 84,044 MW at 60 percent load factor excluding contribution from small schemes. A total of 845 hydro-electric schemes were identified in the various basins which were estimated to yield 442 billion units of electricity. With seasonal energy, the total energy potential was assessed to be 600 billion units per year. In addition, the reassessment studies also identified 56 sites for Pumped Storage Schemes (PSS) with a total installation capacity of about 94,000 MW. The basin-wise estimated hydro power potential thus estimated is given in Table 4.10:

Table - 4.10

Estimated Hydro Power Potential Basinwise

Basin/Rivers	Potential MW at 60 percent Load Factor MW	Potential already developed upto 31.8.98 MW	Potential under development from the on-going projects as on 31.8.98 MW
Indus	19988	2935.85	1332.83
Ganga	10715	1850.33	1147.55
Central Indian Rivers	2740	634.33	1528.00
West-flowing Rivers	6149	3445.33	756.13
East-flowing Rivers	9532	3661.42	701.32
Brahmaputra	34920	452.67	366.72
Total	**84044**	**12979.93**	**5832.55**

Source: CEA

Note : The Great Indus basin comprises six major rivers namely Indus, Jhelum, Chenab, Ravi, Beas and Sutlej. The water resource development of these rivers is governed by the Indus Water Treaty, 1960 signed between India and Pakistan. For the purpose of this Treaty, the Sutlej, Beas and Ravi are called the Eastern Rivers and other three viz. Chenab, Jhelum and Indus, the Western Rivers. As per the Treaty, India can exploit fully the resources of the three Eastern rivers. The Treaty, however, has provisions to enable development of hydro power potential of the Western Rivers by India within the Indian territory under certain limitations on the extent of storage and location etc. While assessing the potential of Indus basin all these factors have been taken into account.

The potential of a hydro electric project represents the energy content of the scheme and is being expressed at 60 percent load factor which has been considered common basis for operating a system involving various modes of generation. The potential in MW at 60 percent L.F. merely conveys that the output using full potential would be generated on continuous pattern for 60 percent time in a day (for about 14.5 hrs). The installed capacity of hydro power projects would, however, vary from project to project in view of their type and actual load factor of operation. Therefore, the installed capacity of hydro power projects requires to be fixed, taking into consideration the requirement of peaking in an interconnected grid and would vary from project to project. If a hydro power project was to operate at 15 percent load factor for supply of power during peak demand, the project of potential of say 100 MW at 60 percent load factor would call for installation of 400 MW, since both these modes of operation would provide the same energy content. Hydro power project could, thus, obviate the need for installing thermal power station of a capacity equivalent to peaking requirement from the thermal station. Basinwise hydro power potential is depicted in Fig. 4.4

As on August,1998, the hydro-electric schemes in operation account for only 15.44 percent and those under execution account for 6.94 percent of the total possible potential at 60 percent load factor. The basin-wise and Region/Statewise details of potential and its Status of development are given at Annexure-4.5 & Annexure-4.6 respectively.

In addition, a systematic study for the development of small hydro potential has been completed in 1996 by the CEA. As per this assessment, 1,512 small hydro-electric schemes having aggregate installed capacity of nearly 6,782 MW on canal falls/rivers, have been identified. The State-wise/region-wise break-up of small potential is given at Annexure-4.7.

It is recommended that such reassessments should be made periodically keeping in view the consumptive requirements from upstream of the reservoir and from the reservoir itself according to the state plans since such requirements for irrigation and water supply would generally enjoy higher priority of use and would result in lower hydro power generation.

4.29 Trends of Development of Hydro Power Potential

The first hydro power project in India dates back to almost a century to the year 1897 when a small station, Sidrapong, with a capacity of 2x65 kW was commissioned at Darjeeling. The pace of progress of power development including hydro power development upto Independence was rather tardy, with a total installed capacity of 1,362 MW. The hydro power capacity addition was only 508 MW in a period of 50 years since the first hydro power station was constructed in 1897. Soon after Independence, the need to generate more power for the country's all-round development was recognised and the pace was accelerated.

Since Independence, hydro power development has experienced a steady rise from 508 MW in 1947 to 22,007 MW (as on August, 98). The share of hydro power in the total installed capacity rose upto 50.62 percent in 1963 but thereafter experienced a steady decline and at present accounts for only 24.85 percent of the total capacity. The year-wise figures of total capacity, hydro capacity and share of hydro power are given at Annexure-4.8. The increased share of hydro power upto 1963 may be attributed to the high priority being accorded to irrigation and the implementation of a number of multipurpose river valley projects. With the growing demand for power, emphasis shifted to coal-based thermal projects, many at the pit heads due to shorter gestation period as compared to hydro power projects.

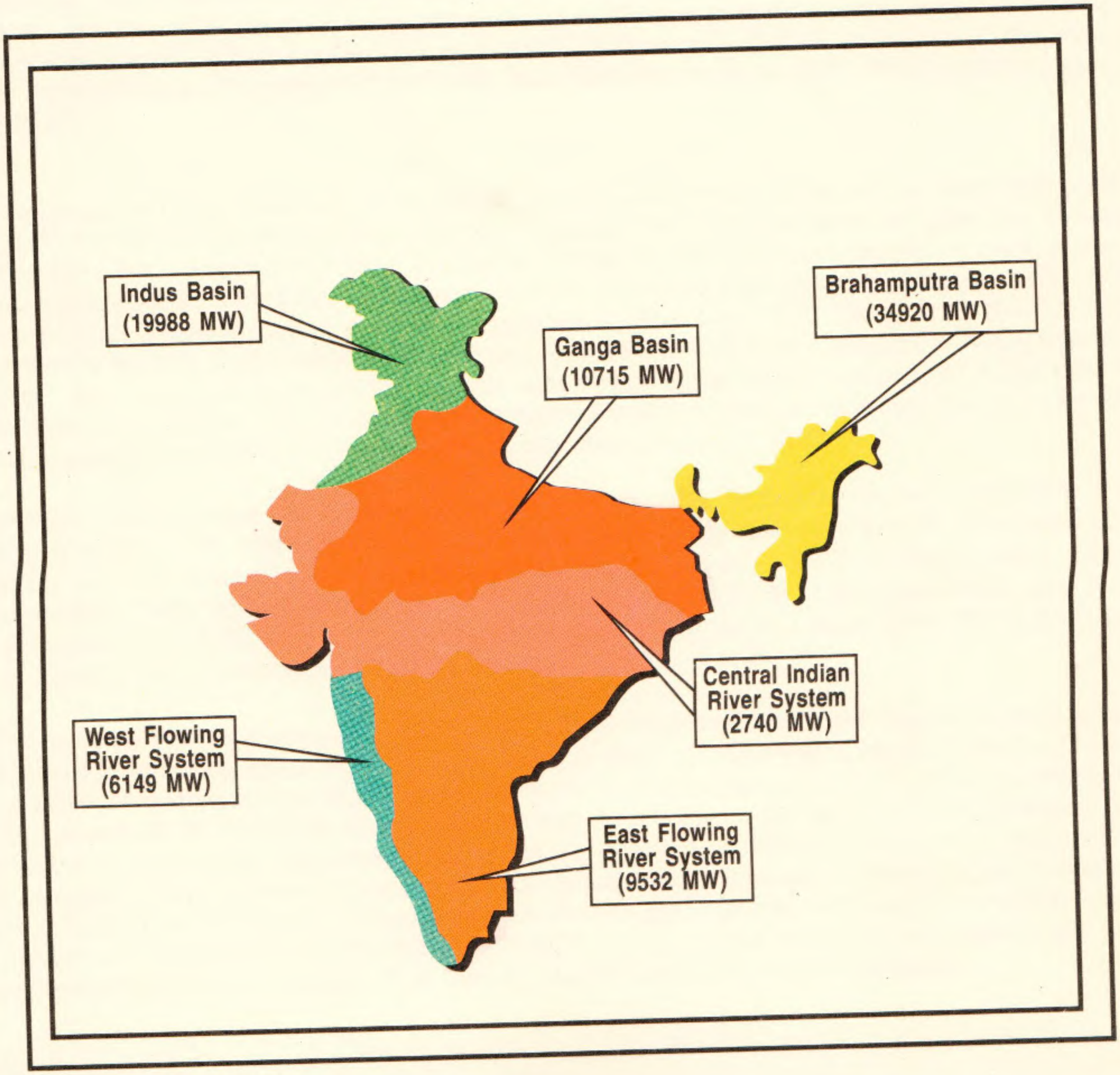
4.30 Reasons for Slow Development

There are many reasons for the slow development of hydropower. There is the challenge to balance the requirements of development with the need to preserve the environment or to limit the adverse impact on environment and the affected people to the minimum. This takes a long time and manifests itself through delays in getting forest and environmental clearance and on the issue of resettlement and rehabilitation of affected people. In addition, there are also other reasons in the system, such as,

- Inadequate investigation and preparation of project reports without considering all relevant aspects and possible alternatives;
- Inter-state nature of the projects and issues connected with it;
- Delays in processing of the proposals in the CWC and other Central agencies;
- Delays in the provision of adequate funds by concerned states;
- Delays in land acquisition;
- Delays in implementation and construction due to contract problems; and
- Law and order situation in certain areas.

Out of these, those internal to the system should be set right first through more thorough investigation, speedy appraisal and time bound implementation.

FIG 4.4 : BASIN WISE HYDRO POWER POTENTIAL OF INDIA



Source : CBIP Atlas-1996

4.31 Measures taken to accelerate Hydro Power Development

The Government of India have taken a number of measures in recent years, to step up investment on hydropower:

Power Corporations at Central Level: The Government has created Hydro Power Corporations in the central sector and the joint sector (Centre and State) such as National Hydroelectric Power Corporation(NHPC), North Eastern Electric Power Corporation(NEEPC), Nathpa Jhakri Power Corporation(NJPC) and Tehri Hydropower Development Corporation(THDC) besides Bhakra Beas Management Board(BBMB) and Damodar Valley Corporation (DVC). Further keeping in view the problems of fund constraints, Power Finance Corporation(PFC) was also created to finance the power projects. Besides, NTPC has also been authorised to participate in hydro development. At present, in Central/Joint Sector, 10 hydro power schemes (2,365 MW) are in operation, 9 projects (4,480 MW) are under construction and 6 projects (2,545 MW) have been approved by CEA. The details are given in Annexure-4.9.

Encouragement to Private Participation: At present, eight hydroelectric projects with an aggregate capacity of 471.75 MW are in the private sector and four projects with a total intallation of 1,186 MW are under construction. The Government of India formulated a policy in 1991 to encourage greater participation by private entrepreneurs from India and abroad. Several incentives were added in January, 1995. Hydro power projects involving capital expenditure upto Rs. 250 crores (MOU route) and Rs.1,000 crores (Competitive Bidding Route) have been exempted from TEC of CEA except projects involving inter-state aspects. As a result, 13 hydro electric projects with an aggregate installed capacity of 4,328 MW have been received in CEA for execution in Private Sector of which in-principle clearance has been accorded for five projects. The status of these schemes is indicated in Annexure 4.10.

Renovation, Modernisation and Uprating (R, M & U): Renovation, Modernisation and Uprating is a well proven strategy. The benefits accrue in less time and at a less cost compared to new hydro power projects. On the recommendation of a National Committee set up in 1987, 55 hydro power schemes were identified with an aggregate capacity of 9,653 MW for R, M & U purpose, which would yield capacity addition of 2,531 MW at an estimated cost of Rs 1,439 crores. Out of these 55 schemes, work on 24 schemes has been completed, which has given a benefit of 1,033 MW.

Policy on Hydro Power Development: In August,1998,the Government of India has announced a policy which aims at removing the constraints in the pace of hydro development mentioned above. The need to reassess the hydro power potential was recognised. Due to inadequacies in the previous surveys,such as non availability of data regarding topography and inadequate hydrological and meteorological data, and lack of full information regarding consumptive use of water in state plans, the realistic potential was not assessed. Now, updated topographical and hydrological information in present and perspective water utilisation plans of the concerned state governments would be taken into account and potential will be reviewed in consultation with the Ministry of MOEF. Such a review would be more realistic and would expedite the hydro electric projects since their scope and size would be clearly defined.

Policy Recognising the Important Role of Small Projects: Small hydro electric projects provide electrical energy in decentralised locations and in some hilly areas where extension of grid system becomes uneconomical. Small hydro power potential is available on small rivers, canal heads and canal drops.

In order to promote small hydro power development, Government of India has announced attractive packages under Hydro Policy for exploiting small hydro development. It has decided that small hydro electric schemes upto 25 MW would be dealt with by MNES (Ministry of Non Conventional Energy Schemes) to enable the utilisation of various incentives. There were constraints of funds for this vital activity which resulted delays in project formulation. The World Bank and Asian Development Bank have shown interest towards funding this sector. Concentrated efforts are required to make full use of this facility, so that bankable DPRs using advanced technology are prepared with the help of experienced international consultants.

Pumped Storage Development: This would provide much needed electrical energy to meet the peak demands at an economical cost. Water is pumped from lower reservoir to an upper reservoir using the energy available in off peak hours and hydro power generated during peak demand hours using the water so pumped. In northern, eastern and western regions of India, the hydro proportions in the energy supply is very small (12 to 13 percent). Pumped storages in these regions would meet the rising peak demands at a lower cost compared to new additions of thermal / atomic plants. Pumped storage plants use the energy of thermal / atomic plants in off peak hours, thus, preventing efficiency loss and reducing the plant load factor. The CEA has accordingly undertaken an extensive survey covering the entire country and has identified 56 pumped storage schemes having a potential of 94,000 MW. The status of 14 pumped storage schemes is given in Annexure - 4.11.

The policy contains measures for accelerating land acquisition, resettlement and rehabilitation and catchment area development. It also deals with rationalisation of hydro power tariff.

The Commission would recommend the following measures, in addition to those initiated by the government:

The details of the resettlement and rehabilitation policy, which has been under consideration for sometime now, may be finalised early. This important aspect is discussed in chapter - 12 on Water Quality and Environmental Aspects.

Steps should be taken to reduce the long gestation period besides conducting thorough investigation, explorations and preparing DPRs taking into consideration the guidelines of MOEF and taking steps for early approval both at the State and/or the Central level. Advance action should be taken to provide the infrastructure facilities such as roads, assessment of quality/quantity of construction material and preparation of detailed contract documents. It has to be remembered that a project which is well planned, well investigated and let out under a well prepared and unambiguous contract document would provide a good start and hold promise for timely execution and help prevent contractual disputes and allegations. The preparation of realistic programmes, both physical and financial and monitoring the same using latest techniques such as PERT and other softwares, would generate status reports which could be reviewed from time to time and remedial action taken. It is also necessary that decision making process is decentralised and quick decisions are taken at all levels.

At present, in the private sector, eight hydro-electric projects with an aggregate capacity of 471.75 MW are already under operation and four hydro-electric projects with a total installation of 1,186 MW are under construction.

4.32 Future of Hydro Power Development

CEA has formulated the Fourth National Power Plan (1997-2012) to provide strategic directions for future power development upto the end of Eleventh Plan as tabulated below:

		Capacity Addition (MW)		
		9th Plan	10th Plan	11th Plan
A)	High hydro scenario			
	Total	49530	45682	55593
	Hydro	17380	18822	25713
B)	Low Hydro scenario			
	Total	52820	45370	57572
	Hydro	8413	18060	17562

The Planning Commission has identified a total of 40,245.2 MW capacity additions during the Ninth Plan, of which hydropower is 9,818 MW, with the following break-up:

Central Sector	3,455.0 MW
State Sector	5,808.0 MW
Private Sector	555.0 MW
Total	9,818.0 MW

At present, 61 schemes with an aggregate installed capacity of 15,899.95 MW are sanctioned/ongoing, 21 schemes with total installation of 7,834 MW have been cleared/appraised by CEA and are awaiting investment decision, 21 schemes with a total installed capacity of 6,156.5 MW are under examination in CEA/CWC and 143 projects with proposed aggregate installation of about 43,400 MW are under various stages of investigation.

The power scenario, especially that of hydro power, is not encouraging. Hydro capacity additions have not kept pace with thermal additions, for maintaining desired relative proportions. Power development through IPPs, especially for hydro power development, has not been encouraging so far. The hydro generating capacity addition in the Eighth Plan has been only 2,428 MW against the plan target of 9,282 MW. The Ninth Plan projections are higher (9,818 MW) which could be achieved only through internal resource generation, loan from International Funding Agencies/Bilateral Funding, private sector participation, removal of various bottlenecks and constraints. It is estimated that even if all the targeted hydro capacity addition of 9,818 MW is realised during Ninth Plan, the hydro share in the total system capacity would be hardly 23 percent.

In view of these, there is an urgent need to evolve suitable strategies for accelerating the pace of hydro power development. In north-eastern region and Jammu & Kashmir where there is large hydro power potential but the transmission cost to consuming centres are high, energy intensive industries could be located close to the hydro project sites. This would attract private participation and accelerate hydro-power development. The other measures suggested for the purpose may be classified broadly in two parts; the first as a short term strategy and the second as a long term strategy. The short term measures include - full financial support to public sector on-going schemes, thorough survey and investigations and preparation of DPRs strictly in accordance with norms, effective monitoring, sorting out implementation problems where necessary, completion of R&M and Uprating of undertaken plants, small hydro development, etc.

The long term strategies include creation of hydro development fund, expediting the hydro power potential review in consonance with environmental concerns and resolution of inter-state disputes in case of attractive projects, promotion of Joint ventures, tariff rationalisation, attractive R&R policy etc. The recent announcement on Policy for Hydro Power Development, referred to above, would certainly help in giving a push to hydro electric development in the country, but effective and integrated implementation is vital for its success.

IV. Inland Water Transport

4.33 General

Inland Water Transport (IWT) cannot be left out of water resources planning, since for the rivers to be navigable, there has to be a water course of sufficient depth and width. As more and more water is extracted, available draft gets reduced for economic navigation.

Inland Water Transport used to occupy a very important place in the transport system of yester years in India and had developed much earlier than other modes of transport. However, with the advent of railways and modern highways coupled with the poor organisation and management of river services, navigation in the rivers gradually declined and inland water transport lost its importance with the passage of time. Heavy siltation in the lower reaches also rendered established facilities out of use. At present cargo transportation in an organised manner is confined to the States of Goa, West Bengal, Assam and Kerala.

The navigable inland waterways in India comprising river systems, canals, backwater, creeks and tidal inlets extend to about 14,500 km. Of these, about 7,800 km is navigable by country crafts. however, due to draft restrictions, navigations by mechanised craft is possible only for about a length of 5,200 km in major rivers and 485 km in canals. The reasons for such low utilisation of the waterways are attributable to the non-maintenance of navigable channels and low cargo offerings.

The rivers like Ganga, Brahmaputra, Mahanadi, Narmada, Godavari, Krishna, Mandovi and Zuari, Tapi, the waterways of Sunderbans, the creeks in the east and west coasts, etc. provide facilities for inland water transport. Some of the important canals having navigation potential are the Cumbarjua canal in Goa, Buckingham Canal in Andhra Pradesh and Tamil Nadu, West Coast Canal in Kerala, DVC and Krishtopur Canal in West Bengal and Orissa Coast Canal in Orissa. The total navigable length of canals is about 4,300 km. However, navigation by mechanised crafts is presently done only for short lengths.

The total cargo moved by IWT is presently about 16 MT. corresponding to just over one billion tonne-km out of the total inland cargo of about 900 billion tonne km. Lack of infrastructural facilities, lack of facilities for door to door delivery and need for large investments are the main reasons for the slow pace of growth of IWT.

In recent years, there has been a revival of interest in IWT. The existing transport corridors are saturated and the railways and roads which carry a major share of passenger and cargo traffic, continue to fall short of demand. Even bulk commodities like coal are moved over long distances by road. As economic growth accelerates transport demand will grow at a faster pace and it will be wise to use IWT for movement of bulk commodities.

4.34 Economics of the Competing Modes

Rail and road modes face constraints because of land use and environmental factors, further complicated by the energy crisis. By the year 2000, India will be spending 74percent of its export earnings on oil imports. The alternative mode of energy efficient, cost effective IWT, therefore, deserves reckoning. Water transportation is the most fuel efficient method of moving freight with the lowest level of emission as can be seen from below :

Mode	Fuel Consumption (Litres of H.S.D. per tonne-km	Fuel efficiency (Ton-mile per gallon)	Emissions (lbs. Per 100 ton-miles)		
			Hydro Carbon	Carbon monoxide	Nitrous Oxide
Rail	0.011	202	0.46	0.64	1.83
Road	0.04	59	0.63	1.90	10.17
IWT	0.0056	514	0.09	0.20	0.53

Source : Theme Paper 1999 IWRS - Vision 2050

According to recent studies carried out for the north east region, the investment cost for IWT works out to Rs.1.37 per tonne-km. Against this, the road system costs approximately Rs.2 per tonne-km and the railway system costs about Rs.2.25 per tonne km.

4.35 Present Status of Development

In the development of water ways for IWT, there are many problems such as bank erosion, siltation, shallow depths, shifting channels, sand bars and lack of infrastructure. Conservancy measures such as bank protection works, revetments, river training, dredging and construction of modern terminal facilities are required in most of the waterways. Infrastructural facilities are essentially to be provided by the government. These facilities include assured fairway with navigational aids (including night navigation) and well equipped ports. For want of these facilities, private agencies are not keen to invest in the IWT.

The Inland Waterways Authority of India (IWAI), set up in 1986, has been charged with the responsibility of developing navigation on national waterways. So far, the following have been declared as national waterways.

National Waterway No.1(The Ganga)

The Ganga-Bhagirathi-Hooghly river system from Allahabad to Haldia (1,620 km) was declared as National Waterway No.1 vide National Waterway (Allahabad-Haldia Stretch of the Ganga - Bhagirathi Hooghly river) Act, 1982 (49 of 1982). It became operative from 27 October, 1986 after the formation of the IWAI. The Hooghly river portion of the waterway from Haldia to Nabadwip is tidal.

From Nabadwip to Jangipur the waterway is formed by Bhagirathi river, which is a regulated because of the barrages at Farakka and Jangipur and where a navigable depth of 2 m is maintained throughout the year. The Feeder Canal and the navigation lock at Farakka become the link between the Bhagirathi and main Ganga up-stream of the Farakka barrage. Public sector Central Inland Water Transport Corporation (CIWTC) and private operators operate vessels between Haldia and Varanasi.

National Waterway No.2 (The Brahmaputra)

The Brahmaputra from Dhubri to Sadiya (891 km) was declared as National Waterway No.2 vide National Waterway (Sadiya-Dhubri stretch of the Brahmaputra river) Act, 1988 (40 of 1988). Under an agreement with the Government of Bangladesh, the CIWTC and other Indian vessel operators are plying their cargo vessels between Assam and Calcutta region making use of IWT transit facilities through Bangladesh. Public Sector CIWTC, IWT Assam and private operators operate in Calcutta-Pandu-Dibrugarh sector.

National Waterway No.3 (The West Coast Canal)

The West Coast Canal from Kottapuram to Kollam was declared as National Waterway No.3 vide National Waterway (Kollam-Kottapuram stretch of West Coast Canal and Champakara and Udyogmandal Canals) Act, 1992 (33-F of 1992) and notified on 1st February 1993. From Kottapuram to Kollam including Champakara and Udyogmandal canals it has a navigable length of 205 km. The waterway comprises of natural lakes, back-waters, river sections and man-made canal sections. Cargo vessels of public sector and private operators operate in the Champakara, Udyogmandal routes and Kochi-Edapallikota route.

The other potential national waterways are the Sunderbans, Godavari, Krishna, Mahanadi, Narmada, Mandovi, Zuari Rivers and Cumberjua Canal in Goa, and the Tapi.

4.36 Future Development and Plans

The inland cargo estimated to be moved by 2000 would be to the tune of 1,200 billion tonne-km. Though estimates for 2050 are readily not available, the inland cargo to be moved would be very high. The present transport modes i.e. the road and rail, have been stretched to their limits.

If necessary infrastructure is provided and the reliability of IWT operation is demonstrated, a shift of mode from road to IWT will be automatic, propelled by market forces. A shift of 20 billion tonne km to the IWT would result in an annual fuel saving of about Rs.500 crores and the annual savings on cost of transportation would be about Rs.900 crores in comparison to the cost of transportation by road.

IWT development needs basic infrastructure like the fairway, terminals and navigational aids. It is unlikely that agencies other than Government would come forward at this stage to put up sizable investment, as return on investment in such infrastructure is not yet clearly visible. It is imperative that creation of these facilities should be undertaken by the government and thereafter, it is axiomatic that market forces will take over.

For a target of 20 billion-km, the anticipated requirement of fleet would be to the tune of 1,200 inland vessels of average 600 tonne capacity. There would be a need to import inland vessels. The private sector should play a major role in this area.

River management and navigational options can not, therefore, be developed in isolation. Close coordination between different water uses is essential. Basic data of all the waterways is readily available with CWC/MOWR. Developing the irrigation canals, most of them being non-perennial, may not be sustainable as modification of canal structures, provision of navigational locks etc. may prove to be economically nonviable.

Ample scope exists for research for river improvement, navigation, vessel design etc. to suit the particular waterway conditions. The experience available worldwide will help to achieve better efficiency and cost effectiveness. There is also need to train personnel for dredging and other conservancy works. The IWAI has to work in close co-ordination with central and state water resources departments.

Integrated development of all modes of transport would facilitate the movement of long distance cargo by the cheapest mode available. According to a recent RITES study, short distance and piecemeal freight could be moved by road which is most economical for leads upto 160 km. The growing mismatch in the movement of bulk commodities and general goods can be eliminated significantly with the introduction of multi-modalism. For example, use of IWT in combination with truck services is the most advantageous pattern for movement of goods between Calcutta and the North-East.

Though IWT service is slow compared to rail and road transport in terms of km per hour, if the total delivery time from the point of origin to the point of destination is considered, IWT can compete with the other modes, once this service is operated round the clock. For example, the average movement of a rail wagon is about 150 km/day. Same is achieved by IWT also. Reliability of delivery time decides the choice of a particular mode of transport since inventory costs are high when delivery is uncertain.

With proper development, the IWT mode would become competitive and would attract cargo in all potential inland waterways. Further, IWT should be treated as a nascent industry as recommended by the Steering Committee on Transport Planning (1988), as some waterways may not be financially viable in the initial period. Water front development programmes and rebates for investments are necessary to bring traffic generating activity back to the rivers. The inherent advantages of lower operational costs, fuel conservation and comparative safety of operations in inland water transportation can be availed of only by adopting necessary policy measures.

CHAPTER - 5

DEVELOPMENT AND MANAGEMENT ISSUES
DOMESTIC, INDUSTRIAL AND OTHER USES

I. Water for Domestic Uses

Safe water is essential for sustenance of life. It is needed for drinking, cooking, washing and cleaning in households. In small towns and rural areas, households need water for maintenance of cattle, in addition to other uses. Many households use water for kitchen garden and in towns and cities for ornamental plants and lawns. Drinking water is a basic need, but it is only one among the domestic uses. Yet, because of convenience, all domestic uses are taken together.

5.1 Requirement for Domestic Uses

Domestic water requirement is mostly of non-consumptive nature. In chapter 3, we have indicated the water requirements for domestic uses for the years 2010, 2025 and 2050 AD on the basis of both higher and lower levels of projection of population growth and on gradual increase of supply norms from the present levels of 125 lpcd for urban and 40 lpcd for rural to 220 lpcd and 150 lpcd respectively (Tables 3.25 and 3.26). Even assuming the higher rate of population growth, which would mean a population of 1,581 million by the year 2050 with sixty percent of that population in urban areas and the liberal norms of supply, the total water requirement for domestic uses by the year 2050 has been estimated as 111.00 Km^3. Taken overall, this does not appear to be a large quantity. The main problem is one of development and management to ensure availability at all habitats.

5.2 Development Issues in Domestic Water Supply

Prior to independence, organised water supply schemes were undertaken only in cities and a few major towns. For the most part, people were dependent on wells, ponds and running water (wherever available). After independence, the Environment Hygiene Committee (1949) recommended that safe drinking water should be provided to cover 90 percent of the country's population in a period of four decades. The National water supply and sanitation programme was started in the first five year plan. Initially, the outlays were small, but they were stepped up substantially from the sixth plan onwards. With the launching of the international drinking water supply and sanitation programme in 1981, the outlays were further enhanced. The Indian programme for the decade (1981-1990) was to provide adequate safe drinking water facilities to the entire population in both urban and rural areas and sanitation facilities for 80 percent of the urban areas and 25 percent of the rural population. However, after a mid-decade review, the targets were scaled down to 90 percent in the case of urban water supply , 85 percent for rural water supply and 50 percent for urban sanitation and five percent for rural sanitation. In view of the slow progress, a National Technology Mission for drinking water was started in 1986 - renamed as Rajiv Gandhi National Drinking Water Mission (RGNDWM) in 1991 - to pool together all the available scientific, technological and organisational skills by the state governments, in order to provide drinking water facilities to all problem villages, numbering more than 1,62,000, before the end of the decade.In 1987, the National Water Policy gave overriding priority to drinking water over other uses and inclusion of a provision for it was made mandatory in all water development projects. As a result of all this, according to official figures, 90 percent of urban population has been covered by now with urban water supply and 50 percent by sanitation facilities. The coverage, however, varies widely. Out of 299 class I cities, only 77 cities have 100 per cent coverage. In 158 cities, there is 75 per cent and more and in 43 cities, 50 percent. There is also considerable variation in the per capita water supply to urban areas; it ranges from 9 lpcd to 584 lpcd and in rural areas from 5 lpcd to 70 lpcd. In the rural areas, 97 percent of rural population is said to have been covered, leaving a balance of around 30,000 NC (Non covered) and 1.50 Lakh PC(Partially covered) habitats.

The Ninth plan strategy for rural water supply seeks to attain universal coverage of drinking water in no source villages/habitations so that at the end of the plan (2002 AD), every habitation has access to potable drinking water. A habitation based approach is to be adopted instead of a village centered one. The highest priority is to be given to all the remaining "no-source" and "poorly served" (less than 10 lpcd) villages/habitations as well as those facing acute water quality problems. Thereafter, prioirty is to be given to other partially covered (11-40 lpcd) and water quality problem habitats. In each category, completion of ongoing schemes is to be given preference over new schemes.

The Planning Commission's projections are based on a minimum of 40 lpcd in all rural habitats. The Chief Ministers' conference on water supply held in July, 1996 suggested, inter alia, that the minimum norm for rural areas should be raised to 55 lpcd and that the distance norm should be reduced from 1.6 km to 0.5 km in the plains and to 100 metre vertical distance in hill areas. For urban areas, the Planning Commission has adopted a norm of 125 lpcd where piped water supply and underground sewerage system are available and 70 lpcd, where no sewerage system is available.

It has been estimated that to achieve the goals of the Ninth Plan, the following outlays will be necessary:

Urban water supply & sanitation	Rs. 26,300 crores
Rural water supply and sanitation	Rs. 40,000 crores
Total :	Rs. 66,300 crores

Source: Ninth Five Year Plan, Volume-II.

The Ninth Plan document shows that the total plan outlay under water supply and sanitation will be Rs. 39,155 crores only. It follows that unless other means of achieving the targets are considered and implemented, 100 percent coverage envisaged will be further delayed. The shortage in urban sanitation programme will be particularly severe.

The source of water is an important consideration in the development of water supply schemes, as the quality, quantity and cost of development depend on it. Based on studies in four states, namely Andhra Pradesh, Karnataka, Orissa and Maharashtra, it was found that urban water supply systems are based in 25 percent of the cases on ground water, 60 percent on surface water and the rest 15 percent from both. The surface sources are rivers, canals, reservoirs and lakes and subsurface water is from infiltration galleries, collector wells, borewells and deep tubewells.

In the case of large cities, nearby traditional water sources are now either exhausted or will get exhausted soon. Cities, therefore, have to reach out for sources that are far away and very expensive to develop and convey. A few examples are given below:

Name of City	New Source	Distance to New Source, KM
Ahmedabad	River Sabarmati Dharoi Dam	150
Bangalore	River Cauvery (K.R.Sagar)	100
Chennai	River Krishna (Telugu Ganga)	400
Delhi	River Bhagirathi (Tehri Dam)	250
	Renuka Dam (Planning Stage)	280
	Kishau Dam (Planning Stage)	300
Hyderabad	River Krishna (Nagarjunasagar)	160
Mumbai	Bhatsa Dam	54

Elsewhere, because of the growth of competing demands, the availability from a nearby or established source tends to go down. This is particularly so in the case of rural schemes which are mostly based on ground water. The increasing demand from irrigation reduces the life of drinking water source. It aggravates water quality problems and results in brackishness, necessitating the resort to costly deep tube wells and piped water supply systems, in the place of low-cost hand pump systems.

In the development of water sources for domestic use, the most important and challenging issue is, therefore, that of sustainability of source and quality. Because of this, there is a re-emergence of problem villages / habitations from time to time, despite several schemes and programmes.

The development of water supply has been almost entirely government funded, either directly from the budget or with the help of institutional finance from public financing bodies like LIC and HUDCO or with foreign assistance from bilateral and international sources. All the funds put together are not adequate to achieve the objective in a time bound manner. Private sector investment is shy to enter the field even in the case of big cities, because of the very low water rates and the ingrained resistance to increase in rates. There are a few instances of philanthropists or charitable trusts constructing and maintaining water supply systems. The most notable example is Shri Satya Sai Baba Trust of Puttaparthy, which has implemented on its own, a massive water supply project costing Rs. 250 crores in the Anantapur District of Andhra Pradesh, benefitting 730 scarcity and fluoride/salinity affected villages and a few towns. This example is worthy of emulation by business groups, other charitable trusts and foundations.

It is clear, in any case, that efforts by government alone will not be able to solve the problem. The least that needs to be done is to bring about increasing involvement of the beneficiaries in different ways. The supply oriented government programme of development devoid of public participation should give place to a people-oriented demand driven one, in which local governments, neighbourhood committees in urban areas and user-committees in rural areas participate in the development and maintenance of water supply systems.

5.3 Management Issues

Even more than development issues, management issues are critical. Considerably more satisfaction and benefit can be obtained from the present system, if managed efficiently. This is, unfortunately, not the case and we are losing on all counts. Costly systems are constructed, but for want of proper management and maintenance, the benefits are not received by the people who have to incur considerable private costs and have to resort to alternate means or supplementary sources.

The Ministry of Urban Development, with the help of the National Environmental Engineering Research Institute (NEERI), conducted studies on leaks in water distribution systems. Investigations were carried out in 13 cities, including Delhi, Calcutta, Mumbai and Chennai. It was observed that about 17 to 44 percent of the total flow in the distribution system was lost as on account of water through leakages in mains, communication and service pipes and leaking valves. In terms of per-capita supply, this works out to 16 to 92 lpcd. About 82 percent of the leakage occurred in house service connections because of corroded pipes, couplings, ferrules and disused connections. The remaining 18 percent occurred due to leakages in main pipes. The investigations showed that if water mains were kept clean and repairs to valves were done in time, the carrying capacity of pipes could be increased considerably and wastage could be brought down to 10 to 12 percent of the supply.

Poor maintenance of and intermittent supply from the mains compels consumers to resort to collection of water in sumps and over-head tanks and some of them living in high-rise buildings instal booster pumps directly on the mains. Since these are not also properly maintained and cleaned periodically, water quality is affected and in order to make the water potable, filter systems are installed. Again, they are not also maintained properly and add their own contamination after a period of time. Thus, in spite of huge public costs in development, treatment and conveyance and huge private costs in sumps, pumps, boosters, over-head tanks and water-filters, the result is unsatisfactory water ! This is a costly vicious circle, which can be broken only by instilling the discipline of maintenance at every level. The need for high priority to maintenance and for putting in place leak detection and preventive measures, as part of an effective O & M schedule, is obvious. Improved low cost technologies have to be developed and adopted to save cost of construction and maintenance. This is essentially an organisational and management responsibility and utilities should be held accountable for it.

Another important paradigm shift that is necessary is to emphasise demand management. The first step in demand management is to promote a conservation ethic all round and especially among users. Public awareness should be generated through a massive campaign of communication through all available media and by the utility management itself setting an example for conservation. All urban dwellers should be made aware of the source from which water is being brought to the city and from which additional water will have to be brought in the future. They should be aware of the costs involved, not only in financial terms, but also the costs that other communities have to incur in terms of opportunity lost by not using the water.

The utilities on their part have to adopt and implement several conservation measures. The measures for water conservation should include metering of supplies as a matter of policy and increase in tariff rate on a sliding scale. Use of treated effluents, in place of filtered water for horticulture and large gardens, and fitting of waste-not taps on public stand-posts to avoid wastage of water should be encouraged. Public awareness needs to be created for reducing water consumption. Water saved is water produced. Women's participation is to be encouraged to the maximum as they are the major users. Wherever feasible, artificial recharge of ground water and rain-water harvesting have to be encouraged. Instead of constantly looking for new and distant sources of water supply, the local bodies should lay emphasis on water harvesting. This means that the development of water bodies, which either feed reservoirs or permit groundwater recharge, should be encouraged as a source of supply. For this purpose, some state assistance could be extended by way of incentive. The rooftops of various buildings could be used wherever possible as hard catchment of rainwater for use after treatment. The rainwater that falls on the rooftops can be harvested for ground water recharge suitably in the Metropolitan towns especially in large buildings, housing and institutional complexes. Existing building bye-laws have to be suitably amended to encourage construction of underground cisterns for collection of rain water during monsoon for domestic uses. This concept is traditionally practised and known (as "Tanka") to the people in Gujarat, Maharshtra and Rajasthan since long time and needs to be revived and made popular.

5.4 Pricing as Tool for Demand Management

It is necessary to operate water supply systems treating water as an economic good and not as a free commodity. Water pricing systems at present do not cover even the minimum cost of operation and maintenance. Regulation of demand to reduce cost, to avoid wastage and to restrict the use of water by high volume users is an important aspect of pricing. To illustrate, Delhi Jal Board has recently revised its tariff structure for various categories of consumers, namely domestic, commercial and industrial on a sliding scale. The rates have been so fixed that the lavish consumer in each category is required to pay more depending upon consumption, while at the same time care has been taken to fix the minimum tariff per month per connection for general consumers. The rates in the domestic category per kilolitre per month per connection are fixed ranging from Rs. 0.35 (upto 10 kilolitre), Rs. 1.0 (11-20 kilolitre), Rs.1.5 (21-30 kilolitre) and Rs. 3.0 (31 kilolitre and above) with a minimum rate of Rs. 20 plus 50 percent surcharge in all cases for general consumers. Similarly, for the commercial category, the rates vary from Rs. 5 per kilolitre per month per connection plus 50 percent surcharge upto 50 kilolitre and Rs. 10 kilolitre per month per connection plus 50 percent surcharge for consumption beyond 50 kilolitre with a minimum Rs. 100 plus 50 percent surcharge per month per connection for the general category. The industrial category which accounts for the highest consumption is being charged at the rate of Rs. 8 plus 50 percent surcharge per kilo-litre per month upto 50 kilolitre and Rs. 12 plus 50 percent surcharge for consumption between 51 –100 kilolitre and Rs. 15 plus 50 percent surcharge for consumption above 100 kilolitre with a minimum of Rs. 300 plus 50 percent surcharge per connection. This 50 percent surcharge is provided to cover the sewerage charges. Even with the present revision of rates, compared with the cost of production (based on the quantity billed) which is about Rs. 5 per kilolitre(1996-97), the price charged is highly subsidized. Evidence suggests impact on consumption patterns especially at higher levels. Table 5.1 illustrates the prevailing tariff structure (as on 1.1.1997) in other metropolitan cities, namely Calcutta, Mumbai, Bangalore and Ahmadabad.

Table –5.1

Name of City	Domestic	Non-domestic
Calcutta	Rs. 40 to Rs. 96 per month flat rate	Metered Rs. 7 per Kl. Unmetered Rs. 400 to Rs. 2200 per month
Mumbai	Re. 1 to Rs. 2.75 per Kl.	Rs. 11 to Rs. 18 per Kl. Rs. 22 to Rs. 35 per Kl.
Bangalore	Rs. 2.80 to Rs. 3 per Kl.	Rs. 30 to Rs. 58 per Kl.
Ahmedabad	Rs. 3 per Kl.	Rs. 8 per Kl

CALCUTTA'S WATER SUPPLY – PSEUDO – VOLUMETRIC TARIFF

Calcutta's population has rapidly increased from 0.7 million at the beginning of the century to 11.00 million to-date and is expected to increase to 17.62 million by 2015. Calcutta Municipal Corporation does not face water scarcity, as sufficient water is available from Hoogly River and public ground water wells, though the quality of ground water is not good. The major concern is the poor performance of 60-150 years' old conveyance system which has 35 percent unaccounted for water loss, high energy and O & M cost and as result of which supply to a part of the metropolitan area is erratic. Short and long-term plans for next 10 years are expected to increase surface pumping and filtration capacity to 380 MGD besides improving the efficiency of conveyance system. New tariff structure incorporating four components - ferule, the pressure in supply segment leading to user's intake and distance and height of user's intake from supply junction-being established will represent volume of water that potentially can be used by the user. Since the tariff system in vogue differentiates between the connection velocity (ferule) and the type of customer, it is anticipated that the pseudo - volumetric tariff will provide incentives for the users to request for replacement of ferules (to lower diameter) if they feel that they use less water then that being potentially provided to them by their existing ferule. Charges for water are expected to triple compared to Rs. 780 per year being paid at present.

Source : A . Dinar and M. Saleth

There is thus an urgent need for revision of the tariffs in most cities to cover not only the O & M cost but also part of the capital cost, depreciation, debt service, plus some reserve fund. In line with the 74th Amendment to the Constitution and the Approach to the Ninth Five Year Plan, the responsibility for water supply and sewerage services should be devolved upon municipalities. Municipalities should be able to discharge this responsibility directly or through contracts with service providers and should determine coverage, service standards/levels and tariffs. Some municipalities which do not have the capacity to run their own water services will need to discharge their responsibility by contracting with a service operator. In small towns and cities where the municipalities do not have the capacity even to choose a water service operator or to negotiate effectively, it would be necessary for the state Government to assist them.

5.5 Suggested Measures for Revenue Generation

The water supply and sanitation sector which has been treated as a social service and welfare measure will have to become economically viable and sustainable in the long run and for that metering of water supply system and cost recovery would play the most important role. Illegal connections will have to be identified and regularised, wherever feasible. The connections will have to be metered more so for bulk supplies. Meter repair workshops to repair defective meters will have to be established. Since major part of the leakage is found in the distribution system and premises, old and dilapidated pipelines in the distribution system will have to be replaced after carrying out leak detection studies. Restructuring of water pricing is needed in as much as only about one-tenth of one percent of the annual expenditure of an average family is spent on water. In fact, the water pricing structure should have adequate built-in financial deterrent measures so that consumption remains within the allotted quotas (which needs to be decided) and thereby avoid over-use of water, particularly, filtered water. Reasonable water pricing mechanisms on a rising scale based on the average delivery cost of water will have to be worked out and implemented in the urban areas by enacting suitable bye-laws. The state governments will have to do the needful to empower the local body to revise the water tariff periodically without waiting for government approval as is being practised by Kerala Water Authority, Bangalore Water Board etc. For the welfare of the urban poor, water for meeting the minimum requirements may be supplied to them at a subsidised rate which should be a nominal charge so that they realise the importance of treated water supply. But, the affluent sections of the society may be charged at a higher rate based on metered quantity. Concept of levying sewage cess to address the issues in water conservation and environmental protection should be implemented. However, if implemented in isolation, it is likely to lead to perverse incentive to polluters. Ideally, the water supply and liquid waste management schemes should be integrated. For this, it is necessary that no water supply programmes are to be taken up without simultaneous approval of sanitation / waste water disposal programmes. Hence, sewage charges should be levied along with water charges.

5.6 Public Awareness and Participation

We have already mentioned the need to involve local governments and communities in the management of systems. There has been reluctance on the part of some panchayats to take up the responsibility for operating and maintaining rural systems. Similar is the case with users also. This shows that a congenial environment has to be created for motivating the people to come forward and take up operation and maintenance. Such a situation seems possible, if they have themselves installed the facility or have been actively involved throughout and are trained to do simple repairs. Field research shows that users get involved in O & M only when they pay for it and are incharge of the system and are certain that they will have control over the funds collected for O&M and that water supply will be dependable. The idea of involving the community in a phased manner in handling rural schemes has been sucessfully implemented in many bilaterally-assisted schemes and also in projects in which active NGOs have played a major role in mobilising people through motivation, awareness generation and attitudinal changes. Women's participation is particularly important as they are major users of water and have to fetch them from a distance if the local system does not work. The entire development and management of drinking water supply schemes for small populations can be done by Users' Associations, Cooperatives etc., as part of integrated local watershed development programme and construction of borewells and pumps.

COMMUNITY PARTICIPATION – RURAL WATER SUPPLY SCHEMES

Swajal Project in UP

Community participation, in a full fledged manner, right from planning stage of the programme through implementation and up to operation and maintenance stage, has been successfully integrated in the ongoing World Bank assisted Rural Water Supply Programme in parts of Uttar Pradesh, and has been achieved through legally constituted "Village Water & Sanitation Committee" (VWSC) representing the community. Empowerment of women is the salient feature of the programme. Community makes choice of the technology and service levels through specially designed feasibility process. Community has control over the construction funds as well as procurement of materials. NGOs act as social intermediaries, provide flow of information to the community and explain the rules of the game. Transparency in operation is ensured.

KERALA

Community participation in Rural Water Supply (RWS) in Kerala deserves mention and is achieved through formation of representative groups in each habitation/ward covering a population of 2,500. The Ward Water Committees (WWC) carry out extension activities of the water supply programme. Some of the activities are a) site selection for public taps/latrines; b) setting distance norms; c) surveying existing stand posts; d) identifying local problems; e) providing training and information regarding maintenance of public taps and f) establishing link between the users and relevant institutions like Panchayats, Water Authority, health departments and voluntary organisations. Community participation is also ensured in identification, information collection, installation and operation and maintenance.

Maharashtra

Ongoing World Bank - assisted project in Maharashtra State having an outlay of Rs.504 crores covers 1,200 villages and two small towns. While O & M responsibility in respect of single village scheme based on hand pumps etc. rests with village Panchayats, that of group schemes covering villages rests with Zilla Parishads. Water tariff has been recently revised from Rs. 150 to 250 per year in respect of stand post and from Rs. 350 to 450 per year in respect of individual household connection, and it is adequate to cover O & M expenditure. Village level Water Supply and Sanitation Committee (VLWSSC) comprising one representative from each ward and giving 50 percent of representation to women and proportionate representation to SC/ST communities is entrusted with O & M and sanitation.

Source : R G N D W M

5.7 Waste Water Management-Standard of Sewage

The Bureau of Indian Standards (BIS), previously known as the Indian Standards Institution (ISI), has laid down standards for sewage effluents vide IS : 4764-1973, and for industrial effluents vide IS : 2490-1974, as shown in Annexure – 5.1. These tolerance limits are supposed to be the National Guidelines for guiding the various State Pollution Control Boards for prescribing their legally enforceable standards, depending upon the water quality and dilution available in their respective surface water resources, and the type of effluents produced by the different industries. When the industrial waste waters are disposed of in public sewers, then also, their quality has to be checked, by following the standards prescribed by IS: 3306-1974 (Refer col. (5) of Annexure – 5.1.)

Based upon these guidelines, the CPCB has got the standards for the discharge of effluents laid down under the Environment (Protection) Act, 1986, based on the places of discharge, attached as Annexure – 5.2. The Ministry of Environment and Forests through its notification of February 12, 1993 has set target dates for installation of effluent treatment plants and compliance with standards by the industries.

Besides Ganga Action Plan Phase I and II, Govt. of India has taken up similar pollution control measures to clean up other important rivers in the country under the National River Conservation Plan in a phased manner. The rivers include Godavari, Sabarmati, Brahmani, Tapi, Cauvery, Krishna, Mahanadi, Subarnarekha, Narmada, Ken, Sutlej, Tungabhadra, Chambal, Kshipra, Betwa, Wainganga etc. The quality of water in various stretches of the rivers is given in the Annexure - 5.3.

The principle of "Polluter Pays and User Pays" will have to be implemented in right earnest because it is an effective policy that requires domestic household to bear the operational cost of sewage treatment. To make the policy workable, a basic water consumption that is essential to daily living will have to be determined. The lavish users, industrialists and commercial sectors should pay for the sewage treatment.

5.8 Innovative Technologies for Sewage Treatment

Cheaper alternatives for human waste disposal need to be examined and experimented upon with a view to evolving affordable system which can provide universal sanitation coverage in near future. These would be oxidation ponds or waste stabilisation ponds which are low cost, low energy, low maintenance and above all a sustainable method of waste water treatment. With the better understanding of Microbiology and bio-chemistry, Upflow Anaerobic Sludge Blanket (UASB) technology has increasingly been used specially during the implementation of Ganga Action Plan and as a result, it has now become feasible to directly treat organic waste water. Generation of bio-gas during the process has added to the economic value of the treatment. In rural areas bio-gas plants have extensively been installed for production of manure as well as bio-gas. Some of the emerging technologies include Duckweed-Pond Technology, Technology utilising Raw Sewage for Forestry and Artificial Wet Lands/Root Zone Technology. Bio-gas reactors can be added wherever feasible.

5.9 Water Quality and Public Health

Surface water invariably acquires impurities (organic and inorganic) besides contamination from point and non point sources. Such water is required to be treated and purified for removal of impurities and contamination before it can be supplied to the consumers. Water is usually pre-treated in clariflocculators using co-agulants for removal of bulk of impurities. In the final stage, water is passed through filter beds to bring it to the specified standards. It is, however, stilll not fit for drinking and has to be disinfected by chlorination or by ozonozation as per IS: 10500 - 1991 (Annexure- 5.4). Rural water supply heavily depends on groundwater which generally does not require any treatment except for disinfection. In isolated cases, ground water has excess presence of fluorides, chlorides, iron, arsenic and nitrates. Removal of these constituants, when present in excess form, is necessary and special processes have to be adopted for removing them.

Water has environmental health implications because water in adequate quantity and quality is essential for the sustenance of health and hygiene. These include issues of water quality ranging from agro-chemicals, industrial pollution and domestic pollution, impacts of water use on groundwater levels including its depletion. Waterlogging, salinity, soil erosion and siltation, degradation of wetlands and impacts on flora and fauna are other various health-related problems. Many of these problems are less evident to the general population than the more visible quantity-related issues. Groundwater related issues, for instance, are gradual in impact. Similarly, water quality and water quantity issues are inter-linked. The preservation of water quality has direct implications for water supply as water quality determines effective water availability. Besides environmental health implications, water quality also has a direct relation to human health. Potable water and adequate sanitation facilities, undoubtedly, reduce health hazards such as cholera, typhoid, infectious hepatitis and bascillary dysentery. As already stated, the urban water supply system often suffers from contamination because of it being of intermittent nature. Unauthorised installation of booster pumps by users themselves directly on the mains, defective alignment of water and waste water networks causing intermixing of sewage and drinking water, aging of the water supply networks and over exploitation of ground water are some of the other causes of contamination.

Ground water being the principal source of supply in rural areas, over-exploitation and increasing pollution and contamination from point and non-point sources create considerable water quality problems. Excessive fluorides, arsenic and iron cause suffering to large population. They are gradual in their impact and, therefore, all the more insidious. Immediate remedial action should be taken early enough in such cases and for that the system of water quality monitoring and surveillance should be institutionalised.

The Central Pollution Control Board (CPCB) which is the nodal agency for organising water quality monitoring has developed primary water quality criteria for the use of freshwater for various categories of beneficial uses ranging from drinking water, outdoor bathing, propagation of wildlife and fisheries, irrigation, cooling and controlled waste disposal. This is discussed in detail in Chapter – 12 dealing with water quality and environmental aspects.

II. Water for Industrial Uses

5.10 Water requirement for industries in India, is quite small compared to the quantity of water needed in agriculture. However, when industrial demand is concentrated in specific locations, heavy point loads are created on available water resources. Water availability is a major factor in industrial location, since non-availability of quality water and drought conditions have forced some industries to shut down. Industries require water for processing, cooling, boiler feed and miscellaneous uses such as washing,maintenance of yards and domestic requirement in townships. Mostly the industrial uses are non-consumptive, thus making reuse through recycling and other conservation measures possible. The amount of water consumed for any product, therefore, varies widely depending upon the process used, plant efficiency, technology employed, the degree to which water is re-circulated and other factors. There are no fixed norms for water demand for industries but rather a range of values determined by the technology used, selection of plant and process, practice in providing maximum recycling to reduce demand and pollution.

Along with municipal waste, industrial wastes constitute a major source of waste water discharges. Unless treated, industrial waste would contain different kinds of toxic pollutants. Treatment of industrial waste water and recycling are essential to meet standards of effluent water quality.

Industrial wastes like domestic sewage contain suspended, colloidal and dissolved solids of mineral and organic origin. Industrial wastes are treated either by themselves or by combining with domestic sewage before disposal. For many industrial wastes, the polluting constituents are capable of being removed by physical and biological action and the methods are similar to those for domestic sewage. Conventional treatment methods employing activated sludge or trickling filter and the newly developed low cost waste treatment methods, namely, anaerobic lagoon, waste stabilisation pond, mechanically aerated lagoon and oxidation ditch are employed for treatment of industrial wastes.

The industrial sector recorded a compound growth rate of 4.6 percent from 1970-71 to 1979 – 80 and 6.6 percent from 1980-81 to 1989-90 at constant price. It has increased further since then and the ninth plan envisages an annual growth rate of 9.07 percent. Except for some traditional industries like jute, a fairly consistent higher growth is forecast for all industries.

Seventeen categories of industrial groups have been identified for understanding industrial scenario of the country besides small scale and village industry. The Central Pollution Control Board (CPCB) has supplied category - wise water consumption and pollution generation figures for these groups as in Table 5.2.

Table – 5.2

Category Wise Water Requirement / Pollution Load Generation (1996-97)

S. No.	Category of the Industry	Water Requirement, m^3/ton/year	Water Requirement, Mm^3/year 1997	Wastewater Generation, m^3/ton/year production	Total Wastewater Generation, Mm^3/year
1.	Integrated Iron & Steel	22	2626.6	16	763.8
2.	Smelters		11.7	65	9.5
	Copper Smelters	110			
	Zinc Smelters	55			
3.	Petrochemicals & Refinery	17	21.3	13	16.3
4.	Chemicals-Caustic Soda	5.5	8.03	1.0	1.45
5.	Textile & Jute	187.5	4863	150	589
	Man made fiber	220			
	Nylon and Polyster				
	Viscose Rayon	220			
6.	Cement	5.5	418	-	-
7.	Fertilizer				
	Nitrogenous	16.5	147.51	5.0	51.5
	Phosphatic	2.2		0.5	
	Complex	16.5		5.0	
8.	Leather Products (Figure in per day)	40	30.2	28	21
9.	Rubber	6.6	2.66	5.0	2.0
10.	Food Processing		848.8	3.0	375

S. No.	Category of the Industry	Water Requirement, m^3/ton/year	Water Requirement, Mm^3/year 1997	Wastewater Generation, m^3/ton/year production	Total Wastewater Generation, Mm^3/year
	Starch Glucose & Related Products	11			
	Dairy	4.4			
	Maltry	9.35			
	Rice Mills	2.5			
11.	Inorganic Chemicals	5.5	96.8	4.0	70.4
12.	Sugar	2.2	36.2	0.4	5.3
13.	Pharmaceuticals		104.7	-	83.8
14.	Distillary (m^3)	22	3939.8	12	40.15
15.	Pesticide	6.5	3.78	5.0	3.08
16.	Paper & Pulp			175	830
	Agro-residue based	220			
	Waste paper based	82.5	852.5		
	Large Pulp & Paper	275			
	Rayon grade Paper	2.2			
17.	General Engineering		1271.4	175	1016
	Grand total		15282.9	-	*3878.3

** Rough estimate of toxic component is around 40 percent of waste water generated.*
Source : CPCB

Apart from these 17 categories of industries, the small scale and village industries were also taken up for calculating the water requirement. Their requirements are quite modest. The CPCB has also taken inventory of small scale industries and worked out the water consumption for such industries. The quantity of water consumption of the industries in the year 1996-97 is presented in Table 5.3 below:

Table –5.3

Water Consumption by Industries (Year 1996-97)

S. No.	Industry	Mm^3/year
1.	Large & Medium Industries	15,282.92
2.	Small Scale Industries	6,882.15
	Total	22,165.07

Source: See text.

Baseline figures for water requirements in industrial sector were identified for the year 1996-97 for which production figures were available. The computation involved superimposing the minimum per unit water consumption figure on the production figure to get the water requirement for a particular category of industry. For each of the industrial sector, the water requirement was individually calculated. In some sectors, subsectors were identified, based on the type of industry and the difference in technology to work out the water requirements figures. Finally, all the individual water requirements were summed up to estimate the national water requirements.

The per unit water consumption figures were based on the available information from CPCB, and the information obtained form the Industrial Association of that particular sector of industry. In some cases, a reputed unit in the industry was contacted by the Central Water Commission for obtaining the per unit water requirement figures of the sector. The projections for the years 2025 and 2050 have been done based on the sensitivity analysis of the production figures and also the technology upgradation and development of the water conservation practices within the industries for reduction of water demand. The present consumption figures are considered to be the maximum demand.

For Small Scale Industries (SSI), the information on water usage by the various sectors was obtained from the Small Industries Service Institute, under the Ministry of Industries, Govt. of India. The production figures were based on the Ninth Plan Document issued by the Planning Commission (Table 5.4) :

Table – 5.4

Growth Rates of Selected Industry Group-Ninth Plan

S. No.	Industry Group	Growth percent
1	Integrated Iron & Steel	9.2
2	Smelters	5.8
3	Caustic Soda	3.2
4	Textile and Jute	21.4
5	Cement	11.57
6	Fertilizer	11.01
7	Leather Product	8
8	Rubber	5.8
9	Food Products/Processing	5.75
10	Inorganic Chemical	13.9
11	Sugar	6.8
12	Distillery	12.2
13	Pesticide	11.9
14	General Engineering	4.2
15	Petrochemicals & Refinery	7.3
16	Drugs & Pharmaceutical	4.3
17	Paper & Pulp	11.9
Over all growth rate of annual Industrial production		9.07

Source: Ninth Plan

The rates for the growth as observed from the Ninth Plan document are adopted for working out the future production figures of the various industrial sectors. The projected production scenario is given in Annexure –5.5. Based on these assumptions and after detailed deliberations, we have worked out the generated pollution load and projected water requirement in respect of 17 identified Indian industries (Annexure–5.6 & 5.7). As per these assessments, the water requirement for industrial development works out to 70 Km^3 and 103 Km^3 for the time horizon 2025 and 2050 respectively. Since the present consumption figures are considered to be the maximum demand and there is likely to be lot of technology upgradation with the use of water conservation practices by way of low cost no waste technologies, the National Commission after deliberation recommends adoption of lower figures viz. 67 Km^3 and 81 Km^3 respectively as indicated in Chapter – 3 of the report.

5.11 Possibility and Extent of Reuse of Water in Industries

In the subsidised and licensing era of planning in which several industries were monopolies or were functioning in a shortage situation,the sector had no compulsion or incentive for water conservation. Indeed, cases abound where industrial plants including those established in India with foreign collaboration consume 2 to 3.5 times more water per unit of production compared to similar plants operating abroad. The conservation of water by industrial units depends upon the supply price of water, as the higher the price of water, the higher will be the incentive to practise water conservation, which would include (i) economy in water use and (ii) re-cycling and re-use of water after treatment. As stated earlier, there is no fixed demand for water for each industry, as it varies in a given range due to adoption of different technologies.

5.12 Re-cycling and Re-use of Industrial Effluents

Recycling is defined as the internal use of waste water by the original user prior to discharge to a treatment system or other point of disposal. Waste water is recovered, treated or untreated and then recycled for repetitive use by the same user.The term reuse applies to waste waters that are discharged and then withdrawn by a user other than the discharger. Waste waters potentially available for reuse include discharges from municipalities, industries and irrigation. Reclaimed waters after treatment are generally used for "agricultural" irrigation, cooling water, algal cultivation and pisciculture, apart from other industrial uses. India, though predominantly rural, has still a large urban population. The urban centres are also the nuclei of industrial growth. The wastes (effluents), if reused within the industry with/without treatment as permissible would help in minimising fresh water requirements while achieving reduction in waste water volume for final treatment before discharge, deriving economy at both ends. The case of Madras Refineries Limited (MRL) is an eye opener where it is acquiring sewage from the local Municipality for utlising in the refinery after treatment. This was necessitated by the acute shortage of water in that area. According to a recent survey conducted by the CPCB, although about 85 percent of the total number of large and medium water polluting industries in the country have effluent treatment systems, their performance, in most cases, is found to be far from satisfactory.

There is now a global awakening on pollution control through recovery of reusable matter from waste effluents. Table 5.5 below illustrates the range of recoverable matter from industrial waste water:

Table – 5.5

Recoverable Matter from Industrial Wastewater

S. No.	Industry	Recoverable matter
1.	Pulp & Paper	Ligno-sulfonate, sodium salts
2.	Fertilizer (Phosphatic)	Calcium sulphate, fluoride
3.	Petro-chemicals	Acetone, carboxylic acid
4.	Electroplating	Chromium & nickel salts, Silver cyanide
5.	Coke oven	Ammonia, Ammonium sulphate, napthalene, phenol, tar, aromatic organics
6.	Dyestuffs	Anthranilic acid, methylaniline, Potassium & Sodium hydroxide
7.	Textile	Caustic Soda
8.	Distillery	Potassium salts, yeast
9.	Rayon	Zinc, Sodium Sulphate

Source : Tyagi et.al., 1994

Recovery of useable materials and by-products results in saving on the one hand and pollution control and abatement on the other. The amount of wastewater generated in various industries and the percentage of effluent that can be recycled is presented in Table 5.6 :

Table – 5.6

Wastewater Generation from Different Types of Industries and Achievable Reuse (Tyagi et al., 1994)

Industry	Average volume of Wastewater per unit of product	Per cent reuse achievable
Thermal Power Plant	155×10^3 lit/hr/MW	98
Pulp & Paper	250×10^3 lit/tonne	50
Iron and Steel	150×10^3 lit/tonne	40
Pharmaceutical	4.5×10^3 lit/Kg	40
Distillery	15 lit/lit of alcohol	25
Textile	250 lit/Kg cloth	15
Tannery	34 lit/Kg of raw hides	12

Source : Tyagi et.al., 1994

Recycling of waste water industries helps in recovery of certain by-products also. For example, in the sulphuric acid recovery process, the treatment cost of pickle liquor on the basis of 8.5 percent free acid in the liquor, decreases as the quantity of pickle liquor processed is increased. Likewise, in the dairying the conversion in cottage cheese whey into saleable protein supplement eliminates a difficult disposal problem. Similarly, it has been found possible to recover potash from distillery waste and zinc from rayon waste easing pollution problems and at the same time recovering products of commercial value.

Each industry needs effective management strategies. This should be preceded by a comprehensive water audit of the industry concerned. Water audits of some water intensive industries in India by the Bureau of Industrial Costs and Prices show that with a proper water management strategy as well as some capital inputs, it should be possible for Indian industry to conserve water and also reduce pollution levels. Benefits of recovery systems in different industries (which is a lucrative proposition as indicated above with a payback period of 2 to 5 years) are listed in Table 5.7.

Table – 5.7

Benefits of Recovery System in Industries

Industry	Total waste water flow (m^3/d)	Total cost of plant (Rs. $x10^3$)	Net annual recovery (Rs. $x10^3$)	Investment pay back period (yrs.)	Remarks
Textile Industry	6450	4625	4375	1.05	Recycle in process house.
Alcohol Industry	1725	2250	975	2.30	Reuse of energy in process house.
Food Processing	1460	10500	4250	2.47	Recycle for Irrigation/process house and reuse of energy.
Viscose Rayon	4500	200	36	5.5	Recovery and Reuse of Zinc; Foreign Exchange saving.

Source : Tyagi et al., 1994

Control of pollution at source to the extent possible with due regard to techno-economic feasibility would necessitate recycling of wastes at every stage of production. In case of metal processing industries, the waste effluent contains recoverable metals which if not extracted are lost in aqueous solution, resulting in pollution. Taking nickel, zinc etc. as examples, there are various techniques for metal extraction from waste effluent e.g. precipitation, electrolysis and ion-exchange. In case of manufacture of organic chemicals, recovery of organic chemicals is possible and is being practised even in this country, for instance, recovery of dilute acetic acid, resorcinol and meta aminophenol, cumence and alphamethyl styrene.

Root Zone Technology

The root zone technology is basically a man made wetland where wastewater is kept at or above the soil surface for enough time during the year to maintain saturated conditions and appropriate vegetation. The three essential components of the system include the soil, the appropriate vegetation such as reeds, cattails, bulrushes and sedges and the microbial organisms. The system has been used in Europe and U.S.A. for treatment of industrial wastewaters including effluents from textile plant containing over 250 organic chemicals, ammonia liquor from a steel industry and acid mine drainage. COD reductions of 84 percent have been reported from textile plant effluents with COD around 1500 mg/l at hydraulic residence time of 28 days.

Source : Manual on Sewerage and Sewage Treatment, CPHEE

Process industries are major users of water and can recycle or reuse water wastes for lesser duty purpose. Cascade concept is adopted for reusing water discarded from a process requiring higher purity to a process requiring lower purity. If required, a simple treatment process may be interposed between the processes. Water reuse is more economical if included at the design stage by modification of the existing system. In a large number of cases, wastewater is composed of various streams which have varying degree of pollution. The cleaner streams can be easily treated and used for purposes for which water quality does not have to be brought to a high level of purity. Thus, the cost of water which can be recycled or re-used can be kept lower than the marginal cost of one unit of water. Water needed for flushing toilets, watering lawns, air conditioning and cooling can often be drawn from treated effluents.

Irrigation is perhaps the most favoured use of treated wastewater, thereby releasing fresh water sources for drinking and domestic purposes and for such industries which require high quality water such as food processing and pharmaceuticals. Additionally, the nutrients present in treated wastewater are an advantage for agricultural production. Since the requirement for irrigation is several times (3 to 4 times) that of all other uses, domestic and industrial wastewater can be almost totally used for agriculture, after treatment as per BIS standards. Care is necessary to ensure that treated wastewater does not contain toxic matter beyond a threshold level. Otherwise, it may enter the food chain, both aquatic and terrestial. Besides, wastewater can damage fertility of soil and quality of ground water if its constituents are not kept within the prescribed limit. For the most economic disposal of wastewater from various sources, 'Recycling, Re-use, Renovation and Regeneration' (the "4-R Concept") must be practised with utmost keenness. As stated earlier, Recycling refers to repeating the same use and re-use is done by using effluent for other purposes. Renovation refers to treatment to the (tertiary) level so that it is fit for use like fresh water, and regeneration refers to replenishment of a water source in a natural manner. Recycling and re-use have been demonstrated to be cost-effective in a large number of cases, with periods of return of investments ranging from a few months to less than five years. In such circumstances, it makes sense to practise recycling/re-use for economic reasons besides doing so to meet ethical or legal responsibility associated with disposal of wastewater.

Efforts were made to ascertain information relating to the national status on requirement, consumption, reuse potential and actual recycling of industrial effluents in 17 identified polluting industries, national and international benchmarks for water consumption and water reuse in each of these industries and projection of water consumption in each of the 17 industries along with achievable recycling scenario, for the years 2010, 2025 and 2050 from the Apex bodies like the CPCB, Association of Industries of various categories of Industries, the CII and FICCI. The desired information is not available with any of these bodies. Some improvement to the extent of Zero runoff by improving the percentage re-use potential has definitely been made in isolated cases depending upon site requirements and stipulation made by State Pollution Control Board like in Madhya Pradesh.

5.13 Hazardous Waste

In arid and semiarid regions, rainfall being scanty, there is potential for using of treated wastewater on land. On the one hand, there is economic gain from irrigation and on the other, it prevents pollution due to discharge of undiluted waste water into a fresh water source. The beneficiaries in the area, however, are prone to make use of the available water without ascertaining the harmful effects in the long run. This is particularly so in the case of hazardous wastes. The hazardous waste from industries is any residue that may cause significant hazards to human health or the environment unless adequately handled, stored, transported, treated and disposed. The major groups of industries that generate hazardous wastes include inorganic and organic chemicals, petroleum refineries, iron and steel, non-ferrous metals (smelting and refining), leather tanning and finishing, and metal finishing. The major problem in respect of hazardous waste management in India is the absence of a systematic assessment of the quantity and pollution potential of hazardous wastes. Preliminary data gathered by Ministry of Environment & Forests (MOEF), CPCB and institutions like NEERI and National Productivity Council (NPC) suggest that the disposal methods currently practised for hazardous wastes management are not environmentally compatible. Notwithstanding the role of chemical products in improved health and life expectancy, increased agricultural production, enhanced economic opportunities and the quality of life in general, the products and residues of the chemical industry pose unprecedented risks to human health directly through contact or inhalation and indirectly through ingestion of contaminated water or food.Migration of chemicals through ground and surface waters increases contaminants in drinking water sources and in turn are a potential risk to human health. Chemical contamination of vegetation and crops through contaminated irrigation water, application of sludges and deposition of air emissions results in trophic transfer of hazardous chemicals. A variety of health hazards resulting from handling and disposal of hazardous wastes have been documented. The severest amongst these include mutagenic, carcinogenic and teratogenic effects.

CPCB is in the process of identifying criteria for zoning of areas for locating units handling hazardous waste and waste disposal sites. Provisions for proper siting of industrial activity are found in the Environment (Protection) Act, 1986, which authorises the Central Government "to take all such measures as it deems necessary for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution" {Section 3 (1)}. It is, therefore, increasingly becoming important to properly locate the industries associated with potential risks and to properly plan and identify the disposal sites for the wastes generated by these industries. Presently the targets for industrial development are fixed, but the sites for the industries to come up are rarely pre-indicated thereby paving the way for haphazard siting of industries. Site selection is not necessarily based on objective assessment of environmental aspects as the information base available for evaluating impacts and taking decisions on industrial siting is weak. Spatial planning (National/State/Regional/Town level) that internalises environmental considerations into various sectors, namely, housing, traffic & transportation, industry and business, is lacking in the country. Hence, the zones for siting of industries and of disposal of hazardous waste are not readily available and as such, while allowing hazardous industries in semi arid and arid areas and insisting on Zero effluent condition, industrial zoning should be done in a manner that water intensive industries are not permitted. This will be specially applicable to industries releasing toxic effluents. The Ministry of Environment and Forests under the Environmental (Protection) Rules, 1986, issued guidelines for permitting/restricting industries and industrial units in the Dahanu Taluka, Thane District in Maharashtra (Annexure-5.8). Under these guidelines, industries have been classified under three categories viz. Green, Orange and Red. In arid and semi arid area, emphasis should be to promote Green Category of industries failing which Orange Category of industries be permitted with proviso of zero effluent condition. Setting up of Red Category of industries be prohibited all together. Hazardous waste treatment and disposal, therefore, need to be properly planned and sited to protect people and environment form adverse impacts. In addition, there is an urgent need for identification and assessment of abandoned hazardous waste disposal sites and remediation of the affected sites to prevent further damage to human health and environmental quality.

5.14 Water Quality Norms for Various Industries

Water quality norms for various industries are diverse, depending on the nature of the industry and the individual processes using water within that industry. The water used ranges between any water to water of extreme purity. Factors like total hardness and hardness due to Calcium and Magnesium are important requirements. Although temperature is not of much consideration, it is important for water used for cooling in industry. As a matter of fact, many of the industrial processes do not need any good quality and highly treated water. However, it may need water free from bi-carbonates, chlorides, sulphates, iron etc. in order to prevent scale formation, colouring of fabrics etc. As such, many of the present industries are switching over to reuse of recycled waste water to meet their water requirements.

Water for industrial needs is very much affected by its availability, its quality for different production processes and level of technology, cost of treatment to bring it to acceptable standards, waste water disposal facilities, discharge regulations and possibilities of reuse. In our country it is a general tendency to consider the first three factors whereas the other factors are neglected. As already pointed out above, generally the requirement of water for industries is estimated on the basis of per unit of product and extrapolated to the future period. This ignores the important facts, namely (i) substitution or reuse possibilities and (ii) impact of technology changes on water utilisation rate and water quality requirements. Research is being carried out all over the world to re-use the wastewater including intensive efforts for improving the technology of water supply and use, substitution of dry process for wet process, substitution of non water using goods and services and geographic redistribution of activities designed to minimise the cost of water to the user or to the community.

5.15 Strategies for Reducing Industrial Use of Water

The tariff rates have to be prescribed such that the industry is compelled to look into technological interventions leading to reduced use per unit production, which in the end will further reduce generation of pollution load and consequent cost of treatment. National/International benchmarks for water consumption and water re-sue in each of the identified 17 categories of industries should be fixed and efforts made to achieve these benchmarks within a specified time frame, say by the year 2010 AD. Water cess or pollution tax is generally levied and collected by the pollution control boards. Differential rates of cess are charged depending upon the use of water, the rate being higher where pollution load is expected to be more resulting in higher cost of pollution abatement and as such, its effectiveness as a deterrent for economising use of water needs to be looked into in terms of Polluter pays concept.

5.16 Minimum Treatment Concept and Minimum National Standards

It should not be construed, however, that the polluting sources shall be given the advantage of dilution to the extent that they need to provide no pollution control devices at all even in situation where allocated pollutional load to the zoned class of the stretch of the water body is higher than the total pollutional load of all the polluting sources within that stretch. In short, the plea that dilution is a solution where source-pollutional load is less than allocated pollutional load is not an acceptable strategy. Because under that pretext, polluting sources located in a zoned stretch of water body, less crowded for the present, get a blanket clearance of using that stretch of the water body as a sewer and may remain reluctant to install pollution control devices when situation in future demands it. It sets a bad precedent and furthermore other polluting sources may demand similar blanket clearance for using that stretch of the water body as a sewer and make situation difficult for framing optimal basin-wise water quality management programme. It should also be recognised that the phenomenon of dilution and dispersion in the ambient water body is an integral part of the basin-wide water quality management and the management programme should take advantage of its availability provided that certain basic minimal pollution control devices are installed at the polluting sources. While considering the discharge of toxic chemicals such as arsenic, cadmium, chromium (hexavalent), cyanide, lead, mercury and pesticides, the phenomenon of dilution and dispersion in the ambient water body should be kept out of the ambit of consideration. The industry specific effluent standards which are being evolved at the National level are to be recognised as "Minimal National Standards" (henceforth abbreviated as MINAS) and envisage treatment of all wastes to certain minimum standards regardless of the type of waste waters and locations. No State Board is required to relax on the "Minimal National Standards", but if the quality criteria of the ambient water at some reaches warrant stricter effluent quality, the State Boards shall prescribe that and thus would make the Minimal National Standards altered to suit the location. This model is effective in halting the obvious pollution immediately and envisages a steady progress in meeting the water quality objectives. It also provides a fair degree of flexibility to the Regulatory Authority for control of water pollution. The minimum treatment to be provided to any waste water aims at the removal of the pollutants like pathogens by effective disinfection, toxic substances, colloidal and dissolved organic solids, mineral oils and adjustment of pH etc. The acceptability of the MINAS is linked to the techno-economic acceptability of the suggested stage of treatment to the polluter which is possible by linking the annual cost of pollution control measures (capital and capitalized operation, maintenance and repair cost converted into annual cost or annual burden) to the annual turnover of the industry. The stage of treatment whose annual burden remains within the critical percentage of annual turnover is generally accepted as minimal stage of treatment for which the effluent standard is the MINAS.

5.17 Status of Toxic Waste Treatment Facility

Toxic wastes are of two types, namely Solid Toxic Wastes and Toxic Effluents. Specialised treatment facilities exist in the country for selected categories of solid toxic wastes. Detailed guidelines are available for handling and disposal of radio-active solid wastes to conform to National as well as International standards. Special care is taken to ensure that leachates do not contaminate soil surface and/or ground water resources even in the long run. Toxic effluents, however, are not segregated in the industries and are often discharged mixed with other effluents. Generally, waste water of industries such as sugar, distilleries, dairies, tanneries etc. can be treated by biological methods such as stabilisation ponds, activated sludge process, trickling filtration, aerated lagoons etc. Other industrial wastes such as pulp and paper, synthetic fibre etc. have to undergo simple physico-chemical methods of treatment, but the industries discharging toxic wastes such as electro plating, metallurgical, caustic chlorine etc. may require more elaborate techniques. Special treatment facilities are almost non-existent at present. Information provided by agencies like CPCB/State PCB indicate that no reliable data is available in this regard. Therefore, it has not been possible to estimate the economic cost of treating toxic effluents despite detailed guidelines and stipulations under the National/International norms (Bessel convention). However, the selection and zoning of industries needs a thorough analysis and planning before they are set up in any water basin. The concerned State Government and other local bodies should have a coordinated approach in selecting and locating industries of a specific nature with respect to their water requirement and facilities for wastewater disposal. It calls for a concrete policy for zoning the water basins according to the types of industries, quantity of water consumed and quantity of discharges containing toxic effluents. A better plan should be made to reserve and allocate dependable and suitable water resources for the industries in their location so that they can cope with the discharge standards, otherwise it will be very difficult to manage the pollution problems in the coming future.

5.18 Waste Minimisation Needs

It is realized the world over that waste minimization can be achieved through implementation of low and non-waste technologies (LNWT) - which are essentially based on improved manufacturing methods that require less raw material and energy in comparison to technologies giving same levels of output. Accordingly, the emphasis should be on the need for waste reduction on the basis that prevention is better than cure. Earlier, treatment processes to cure effluents were added at the end of manufacturing processes to meet the regulations, but it is now being realised that preventive measures through change of technologies have to be taken as cost for the prevention may be less than cure by treating the effluents at the end of manufacturing processes. The transfer of pollutant from one medium to another may not be considered as a solution. Pollution control via end of pipe treatment processes, only deals with the first generation pollution, created coincidentally with the manufacturing process, ignoring the issues of second generation pollution related to product use problems. As a matter of fact, the preventive approach is synonymous with efficient utilisation of scarce resources, which has the distinct advantage over the curative approach. Waste minimization is not only a matter of technology, but involves planning and organisation, an innovative attitude, good house keeping and sound management practices. LNWT include Clean production technologies having waste minimisation at all points in the cycle of production through process changes, good house keeping, recycling and reuse, equipment redesign and product reformation. The adoption of "Clean Technology" has increased profitability up by 40 percent in the developed countries.

5.19 Desalination of Sea Water and Saline Ground Water

Salinity ingress normally takes place along the sea coast or along the creeks which carry high tidal waters. In addition to this, there are several pockets spread all over the country, situated far away from coastal plains, where there are aquifers with inherent salinity and fresh groundwater areas bordering them are vulnerable to salinity ingress. Groundwater is considered brackish and not suitable for drinking if it contains Total Dissolved Solids (TDS) exceeding 1,500 PPM. Desalination is an option to produce water of desired purity to meet the essential needs of the water for drinking/industry and is basically a separation process that treats saline water to reduce the dissolved salt content to a usable level. The various desalination processes can be classified under the following groups: 1) Distillation, 2) Freezing, 3) Humidification, 4) Chemical and 5) Membranes. Further, there are several techniques available under each of them. However, most commonly accepted processes on commercial scale are Multi-Stage-Flash (MSF), Multi-Effect-Distillation (MED), Reverse Osmosis (RO) and Electrodialysis (ED). The first two are based on thermal desalination processes and the last two on membrane processes. Multi-Stage-Flash is used primarily for desalting sea water when salinity is around 45,000 to 50,000 ppm. Electrodialysis is particularly suitable in cases where brackishness is lower than 5,000 ppm of dissolved salts, whereas in case of brackishness exceeding 5,000 ppm and less than 10,000 ppm of dissolved salts, Reverse Osmosis is globally accepted technology. Reverse Osmosis is also suitable for sea water distillation plants of medium size. Realising the importance of providing safe drinking water to a common man for domestic use in coastal regions, India too has entered the era of desalination since last three decades in 4 areas, where Ground Water is saline. Under Rajiv Gandhi National Drinking Water Mission (RGNDWM), brackishness is identified as one of the sub-mission programmes. The National Survey on the status of drinking water in habitations (1991-93) indicates that about 55,739 habitations are affected with brackish water problem. 194 desalination plants based on membrane technology were approved by the Mission for various states to provide water, free from excess brackishness, in the affected habitations. Under the project, coordinated by CMERI, Durgapur, the Mission sanctioned setting up of 132 desalination plants in various states. Table 5.8 shows the statewise distribution of such plants.

Table –5. 8

Statewsie Distribution of Desalination Plants

S. No.	State	No. of plants commissioned	No. of plants not commissioned	Total No. of Desalination Plants
1.	Andhra Pradesh	11	3	14 (13)
2.	Gujarat	11	1	12 (12)
3.	Haryana	2	0	2 (1)
4.	Maharashtra	2	0	2 (1)
5.	Pondicherry	3	4	7 (5)
6.	Rajasthan	67	4	71 (44)
7.	Tamil Nadu	20	1	21 (19)
8.	West Bengal	1	2	3 (3)
	Total	117	15	132 (98)

Source:Shah et al. (1997)
The figure in the bracket indicates number of RO plants.
53 out of 117 plants commissioned have capacity of 20 m^3 per 16 hr. of operation. Other plants are of capacities 10, 30, 50 and 100 m^3/16 hr.
Total installed capacity of 132 plants is 3,700 m^3 per day. As against this planned capacity, actual capacity of 3,190 m3 per day was commissioned.

The approved capital and operating costs of the projects are given in Table-5.9.

Table –5.9

The Capital, Operational and Maintenance Cost of Desalination Plants

Capacity (M^3/day)	Cost of Plant (Rs. In Lakhs)	Cost of O & M/ year (Rs. In Lakhs)
10	6.0 to 10.0	1.0 to 2.0
20	8.0 to 11.0	2.0 to 2.6
30	9.0 to 14.2	2.6 to 34
50	16.0 to 27.2	3.6 to 6.0
100	20.0 to 41.3	7.0 to 11.0

Source:Shah et al. (1997)

The operating cost of Reverse Osmosis plant will vary with the size of plant, salinity of feed water, electrical charges at specific location, raw water pumping depth, approachability of site and maintenance facility available, design of pretreatment system besides purity requirements which vary with each end use. It is noticed that a large number of plants are not working to expectations and could not supply potable water to village/community as per the contract. The reasons for this as analysed by CSMCRI, Bhavnagar are: improper plant design, improper selection of membrane, inadequate investigation of water quality, particularly iron and chlorine which foul the membrane, non-availability of electric power, non-selection of proper non-corrosive material for construction and untrained staff for operation and maintenance. It is also observed that there was no coordination between plant suppliers and state government agencies. The communities were also not taken into confidence. Appropriate lessons must be learned from this experience, but it should not lead to abandonment of desalination as a possible option. This is a field in which technologies are fast evolving and costs are going down. The water obtained by desalination is costly when compared with the normally treated water. But based on the experience of three RO plants installed in Delhi , the cost of treated water through these plants has been found to be Rs. 40 per Kilolitre, which is less costly than the water supplied through tankers.

5.20 Recreational Uses of Water

Multipurpose River Valley Projects are primarily intended to substantially increase the total quantity of water available to the community by reducing run-off to the sea and once this is achieved, there will be enough water to spare not only for irrigation but also a variety of other needs like navigation, recreation and pisciculture etc. which are either not fully expressed or fully met with today. In general, these do not necessarily involve significant consumptive use of water and therefore, do not figure in planning Water Resources Development. So far as recreation is concerned, it is rarely practicable to design a large reservoir for recreational purposes alone, and as such any recreational benefits are usually incidental to the other functions of the project. The ideal recreational reservoir is one, which remains nearly full during the recreation season to permit boating, fishing, swimming and other water sports. A reservoir subject to large drawdowns is usually unsightly and creates problems of maintaining docks, boat moorings, beaches and other water front facilities in useable conditions.

Man-made reservoirs or ponds or lakes built for the storage of water usually by construction of a dam across a river or a stream form an important part of the Inland Wetland Resources of the country and are one of the most important eco-systems of earth exhibiting a great diversity. The importance of these reservoirs has increased considerably in recent years with growing interest in them for supplementing human dietary requirement and ecological significance in terms of flood control, water purification, aquatic productivity, micro climatic regulation and as habitats of fish, birds and wild life. Some of the reservoirs created for multipurpose projects have gained legendary importance because of scenic beauty created by them besides providing support to the socio-economic life of a large number of persons living around them. Innumerable migratory birds of different sizes, shapes and colours visit these water bodies and these become places of special attraction to the visitors and their natural environments attract a good number of tourists from India and abroad. The diversified floral and faunal assemblage in and around these places draw the attention of many *researchers and workers. Reservoirs created to generate electricity through hydel projects across* major rivers which include Gobind Sagar, Pandoh, Chamera, Macchkund etc. are being used for fishing and aquaculture development besides being places of tourist attraction for skiing and other water sports which provide cheap and pleasant recreational facilities. Pong reservoir across Beas River is the largest artificial wetland which besides impounding water for irrigation purposes, is a sanctuary for variety of migratory avifauna. Similarly, Harike lake in Punjab which came in existence as result of an irrigation barrage built at the confluence of Satluj and Beas rivers in fifties and falls under man-made water riverine system, is an ideal resort for birds as it provides excellent habitats to them for foraging, breeding, roosting and pre-migratory requirements.

Development of garden and recreation areas have taken place around many reservoirs making the environment more pleasant and providing recreational facilities to the people. In general upper reaches of rivers in India offer enough scope for the creation of recreation facilities. Some example are Brindavan Gardens (Krishnarajsagar) and Sant Dyaneswar udyan (Jayakwadi). Government of Gujarat has developed area around Ukai reservoir as a tourist spot. Similarly, a nice garden has been developed around Ravisankar dam in Madhya Pradesh. The forest around reservoir created by Periyar dam is a very popular tourist spot where people can see varieties of wildlife -while boating in the reservoir. Many more examples can be cited. As a matter of fact, easy accessibility to these reservoirs by track or by jeepable roads has encouraged tourism activity around them besides being a substantial source of revenue. With many of the Indian festivals involving mass bathing in the rivers and water bodies, requisite quality and quantity of water in the designated reaches for recreation is imperative. It is essential that these vital sources of recreation, scenic beauty and places of religious congregation are preserved, protected and maintained properly.

CHAPTER – 6

LOCAL WATER RESOURCES DEVELOPMENT AND MANAGEMENT

The need for and benefits from conjunctive use of canal water and local water resources, like those from tanks and ponds and ground water, are generally recognised. Even so, such use is resorted to only where scarcity of irrigation water, in relation to demand, is felt. In other irrigated areas, reliance on canal water, as the sole source, continues. We have already stressed the need for optimum use of local sources of water even in canal irrigated areas, in the interests of efficiency of water use, extension of irrigated land, prevention of water-logging and increased productivity. In this Chapter, we discuss the important question of local water resources development in all its aspects.

6.1 Importance

The local resources of water served the needs of people almost entirely till the end of the last century, though the scales of the requirement were lower than what they are now. It is still the case in un-irrigated areas, except that in addition to or in the place of draw-wells, ground water can be tapped (where available) through mechanical means. The earlier rain-harvesting systems had a pre-eminent position in rural life. Writing about such systems in the former Mysore State, Major Sankey, Chief Engineer observed in 1868:

> "Of the 27,269 square miles covered by Mysore, nearly 60 percent have by the patient industry of its inhabitants, been brought under the tank systems. Except under exceptional circumstances, none of the drainage of these 16, 287 square miles is allowed to escape. To such an extent has the principle of storage been followed that it would now require some ingenuity to discover a site within this great area suitable for a tank".

The tank system was a collection point of runoff, thereby moderating flash floods, providing a pond for pisciculture, a source of silt for fertilizer and material for construction, a recharge structure for ground water, a source of drinking water for livestock and above all an irrigation source for cultivation of crops. Like tanks and ponds, several water conservation measures like nadi, tanka, roof-top collections, step wells, ooranis were followed traditionally in different parts of the country. In more than one way, the tanks constitute soil and water conservation works in the watershed, making them the largest single component of overall watershed development. Similarly, tanks serve to conserve water by recharging groundwater.

At the commencement of the planning era, there were about 5 lakh tanks in the country of which 46,800 had command areas less than 40 hectares each. The total number of irrigation tanks in the country was estimated to have increased to about 15.13 lakh in 1986-87. The concentration of tank irrigation is mainly in eight States, namely Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal, which together account for over 95 percent of the total tank population. Against an assessed total potential of 17.38 Mha under minor surface irrigation works, the potential created is 12.25 Mha(1997). Of this nearly 40 percent has been through tank irrigation. However, due to silting, neglect and irregular maintenance of irrigation tanks, the gross command area came down from 4.78 Mha in the year 1962-63 to 3.07 Mha in the year 1985-86, although thousands of new tanks were added during this period. This would amount to capital loss of about Rs.5,000 crore at the present price level.

With the emphasis on large dams and canal systems and also due to socio-economic changes in rural areas (the collapse of traditional power structures, the non-emergence of a cohesive village community in all places and changes in land holdings etc.), the emphasis on tanks and other local resources waned over the years. The interest and emphasis on local resources also waned because of cultivation, encroachments, deforestation and population pressures in the catchments of the tank systems, their siltation, lack of maintenance and repairs and in several cases breaches and failures. Also responsible were their fast diminishing capacity to receive and hold water, their cost-sharing formulae, and the tendency to look up to the State and Central Governments for larger centralised systems. The higher cost per unit water availability, their limited life, mortality, reliability and dependability, and economic viability were question marks which added to the decline of interest in such systems. But the revival of local systems, through integrated watershed development, is vital for a number of reasons.

The Commission considers renovation and modernisation of tanks and other local water resources as a priority task. The programme needs to be planned and implemented on a watershed basis, taking into account the comparative techno-economic feasibility of renovating existing tanks vis-à-vis construction of supplementary tanks, upstream and downstream. Such a programme should focus on elements like reforestation of the catchment areas of tanks, restoring unlined channels to their original capacity by clearing weeds and silt as well as removing encroachments, strengthening and improving tank bunds or anicuts and other associated structures as the case may be as well as watershed conservation measures along with such improvements or corrections in the distribution network as the users feel necessary. User communities have first hand knowledge and experience of local conditions and local problems which no outside "expert" can match. Their knowledge is valuable in deciding what improvements are needed in specific local context. Spillway capacity may require to be checked and distribution networks require review. Silting of tanks and the possibilities of raising their banks also need to be examined. In southern India tanks are inter-linked by the connecting channels which also require to be reviewed for their capacity for conveying water. With proper designs and planning, the additional benefits through successful implementation of the programme should be much larger than from undertaking new irrigation schemes. Based on such performance review and technical appraisal, feasibility reports on modernisation of the tanks should be prepared.

Centralised water resource systems comprising dams and canals can even in the ultimate stage cover less than one third of cropped area of the country. With inter basin transfer, the coverage could be larger,but as pointed out in next chapter, there are many political, environmental, legal and emotional difficulties; the resources needed are large and the costs of mitigative measures for adverse impacts on environment and of rehabilitation of displaced people are mounting.

In a basin plan, there is a place for the whole range of structures – large to small. The latter has a particularly important role in rainfed regions of the country, which will remain starved of irrigation facilities even in the ultimate stage of irrigation development. Large numbers of small local water management projects in rainfed regions can make a significant dent on the productivity of such lands and provide succour to millions of poor people, while improving local environment and regional ecology, thereby leading to sustainable development of those areas. They have also an important role to play in the upper catchment of rivers, which are full of streams amidst the rolling and undulating terrain. In the latter areas, check dams, contour trenching and bunding, gully-plugging and such other measures help to conserve water. Along with afforestation, they also help in soil conservation and recharge of ground water.

6.2 Past Efforts

The idea of an integrated treatment of all lands in a watershed was adopted by the earliest multipurpose river valley development project, after Independence-namely, the Damodar Valley Project. The Damodar Valley Corporation set up an inter-disciplinary department of soil conservation, which functioned as such and built a series of small tanks and ponds, afforested their catchments, reclaimed land to give "land for land" during future dam construction, and controlled gullies through check dams and plantations. It also introduced production fisheries in the tanks. Over the years, after the project was completed, instead of the experience being replicated, departmentalisation seems to have taken over as in all other fields. In any case, this remained an isolated experiment.

In the 1970s, the idea of integrated watersheds was revived, again by the soil conservation department. The approach was made one of the conditions of financial assistance to the centrally sponsored schemes for the treatment of the catchment areas of selected river valley projects and of flood-prone rivers. The Fourth Five Year Plan proposed comprehensive treatment of all types of lands "on a complete watershed basis". The concept has since been reiterated in all plan documents, the emphasis being on small local watersheds of 1,000 to 2,000 hectares.

A series of integrated development projects for local areas was started in 1970s and early eighties, first by the Ministry of Agriculture and ICAR and later by the Ministry of Rural Development – variously called at different times, dealing with rural area development, employment, poverty alleviation and wasteland development – the Ministry of Planning and Programme Implementation and Ministry of Environment and Forests. There have also been several externally aided projects funded by the World Bank, EEC, KFW, DANIDA, SDC and ODA. A list of the schemes sponsored by the Central Ministries and the externally-aided projects is given in the attached Tables 6.1 and 6.2. Some State Governments like Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, and Rajashtan also started watershed development programmes on their own, with some successes as at Jhabua in Madhya Pradesh.

The Central Ground Water Board, on its part, has suggested and also experimented with a number of measures for artificial recharge of ground water – water spreading, recharge through wells and induced recharge from surface water bodies. Such measures would also form part of integrated watershed development.

The significant points to be noted from all these efforts are : (i) most of the initiatives have come from Government of India often from Ministries, other than the Ministry of Water Resources, which now has a mandate for co-ordination in relation to diverse uses of water, (ii)all the programmes show an unrealised concern for co-ordinated action to achieve the mix of objectives and departmental schemes and the programmes continue as before & (iii) while the recent programmes and guidelines emphasise the necessity for consultation with the participation of the community and the people, as well as equitable distribution of benefits, all of them visualise the government departments and functionaries playing the key role.

A number of social activists and voluntary organisations have shown growing interest in local watershed development, either in itself or as part of integrated development of a village or area. Sukhomajri, Tejpura, Nalgaon, Daltonganj, Ralegon Siddhi, Jawaja, Adgaon. Alwar etc., are well known examples and have been widely discussed and written about. Amongst the many voluntary organisations, the Pani Panchayats of Maharashtra, the contributions of Tarun Bharat Sangh, Mysore Resettlement And Development Agency, Action for Food Programme, Society for Promotion of

TABLE 6.1:MAJOR CENTRALLY SPONSORED PROGRAMMES ON WATERSHED DEVELOPMENT

Programme	Started	Major Objective	Area Covered till end of March, 1999	IX Plan Outlay	Remarks
MOA					
NWDPRA	7th Plan	Conservation and utilisation of land, plant, animal and human resources for sustainable development.	51.57 lakh ha spread over all States and 2 Uts	Rs. 1,030 Crores (75% grant and 25% Loan)	
IWMCFPR	6th Plan	Soil and water conservation in the catchment of flood prone rivers.	10.46 lakh ha in 234 watersheds, 10 catchments in 8 States	Rs. 200 Crores (50% grant and 50% Loan)	
CSSRVP	3rd Plan	Soil and Water Conservation to control pre-mature siltation of reservoir.	36.95 lakh ha covering 29 catchments in 18 States	Rs. 400 Crores (Wholly funded by Centre)	
WDPSCA for NE India	7th Plan	Development of Shifting Cultivation.	1.12 lakh ha covering 7 NE States	Rs. 15 Crores	
MRAE					
DPAP	1973-74	To minimise the adverse effect of drought and restore ecological balance.	87.08 lakh ha covering 947 blocks of 155 districts in 13 States	Rs. 700 Crores	
DDP	1977-78	To control desertification and restore ecological balance.	16.54 lakh ha covering 227 blocks in 36 distircts of 7 States	Rs. 550 Crores	
IWDP	1989	Regeneration of waste land	5,11,000 ha	Rs. 366.5 Crores (Tentative)	
JRY	1989	Employment generation	1,62,399 ha	Rs. 6,267 Crores #	# outlays for 1997-98, 1998-99 and 1999-2000 only. Of the total JRY funds spent during 89-96, the expenditure on soil conservation and land reclamation worked out to 0.729 %.
EAS	1993	Assured employment to those in need.	N.A	Rs. 5,660 Crores ##	# #outlays for 1997-98, 1998-99 and 1999-2000 only. Of the total EAS funds spent during 1996-97, the expenditure on watershed development worked out to 6.45 %.
Grants in Aid Scheme to NGO for Wasteland development	7th Plan	Afforestation and wasteland development.	22,838 ha	Rs. 20 Crores *	* of Rs.20 crores, 50% is for watershed.
MOP					
Western Ghats Developemt Programme	1974-75	Eco-conservation and eco-development.	Designated Talukas of Western Ghats in Maharashtra, Goa, Karnataka, Kerala & Tamil Nadu	Rs. 169.01 Crores @	@ outlays for 1997-98, 1998-99 and 1999-2000 only.
Hill area Development Programme	5th Plan	Eco-preservation and Eco- restoration.	Hill districts of Assam, Tamil Nadu, U.P. and West Bengal	Rs. 972.99 Crores @	-do-

Source : 1 Report of Planning Commission Committee on "Twentyfive Years' Perspective Plan for Development of Rainfed Areas".
2. Data obtained from the concerned Departments/Ministries.

TABLE 6.2: LIST OF ONGOING/COMPLETED EXTERNALLY AIDED PROJECTS ON WATERSHEDS

S. No.	Project	Target	Cost (Rs. In Crore)	Year of Start	Date of Completion
	World Bank Aided Projects				
i	IWDP (Hills) Project	2.46 lakh ha	292.00	1991-92	31-03-99
ii	IWDP (Plains) Project	4.13 lakh ha	265.9	1990-91	31-03-99
	EEC Aided Project				
i	Doon Valley Project	1.41 lakh ha	82.95	1993-94	31-12-2001
	DANIDA Aided Projects				
i	CWDP, Thirunelveli - Phase II	42,500 ha	41.72	1994-95	05.07.2001
ii	CWDP, Karnataka - Phase II	30,000 ha	22.33	1997-98	31.05.2004
iii	CWDP, Koraput	40,000 ha	13.25	1992-93	04.10.99
iv	CWDP, Ramanathapuram	11,000 ha	13.00	1994-95	07.05.2000
v	CWDP, M.P.	33645 ha	13.15	1996-97	13.03.2002
	KFW Aided Projects				
i	Watershed Development Project in Karnataka	53,627 ha	55.08	1994-95	2001-02
ii	Watershed Development Project in Maharashtra Phase - I	10,000 ha	19.73	1990-91	2001-02
iii	Watershed Development Project in Maharashtra Phase - II	-	DM 25.00 Million Rs. 45.00 crores	1996-97	2004-05
	SDC Aided Projects				
i	PAWDI, Rajasthan	15,000 ha	15.34	1995	1999-2000
ii	ISPWD, Karnataka	30,000 ha	20.73	1995	1999-2000
	ODA Assisted				
i	Karnataka Watershed Development	65000 farm families, landless labourers, Village artisans	£ 10.27 Million	1998	2003-04

Source : 1. Report of Planning Commission Committee on"Twentyfive Years' Perspective Plan for Development of Rainfed Areas".
2. Data obtained from the concerned Departments/Ministries.

Wasteland Development and Agakhan Rural Support Programme are quite significant. In Delhi, INTACH has prepared a detailed plan for augmentation of local water resources through restoration of old structures, water-harvesting, conservation and recharge of ground water.

6.3 Lessons of Past Experience

A number of studies and evaluations have been made of the different kinds of programmes and projects undertaken by different agencies. The Report of the Planning Commission's Committee on 'Twentyfive Year's Perspective Plan for the Development of Rainfed Areas' (1997) gives extracts of a number of recent case studies that are very instructive. We give below, in a summary fashion, the more important lessons that could be gleaned from the large number of studies that have been made:

The story of watershed development undertaken thus far, is a mixed one of success and failure, also of initial success and later decline and initial failures and later revival.

Government Programmes

1. Relative to the size of the problems and the potential and the magnitude of resources devoted to these activities, "integrated watershed development" is still in its infancy and at a largely experimental stage ;
2. Even as the local integrated approach was being emphasised and was getting a favourable response from the people, the proliferation of schemes by the Ministries has continued. Each scheme had its own built-in rigidities ;
3. Almost all the 'integrated' programmes remain fragmented in terms of sources of funds and responsibility for implementation. A collage of schemes implemented by different vertical departments does not get automatically coordinated;
4. The co-ordination mechanisms in the form of co-ordination committees were hardly effective ;
5. The absence of provision for follow-up action and continuing management after the completion of a project was a major weakness in all departmentally run centrally sponsored programmes ;
6. Integrated watershed programmes like other area development programmes, were not looked upon with enthusiasm by most departmental heads, who believe more in vertical delivery than in horizontal co-ordination at the local level ;
7. Though people's participation was emphasised, it was mostly formal even when sought. People's involvement at all stages was rarely achieved.

Projects of Voluntary Organisations/Activists/Communities

Compared to government programmes, the projects undertaken by local communities, voluntary organisations and activists were more relevant to each location, had much greater people's involvement and were flexible and innovative. They have also shown keenness to evolve cost-effective techniques and to use local traditional knowledge. They had also several important lessons; some of the more important of these are:

1. The mutual relationships among the voluntary organisation, the beneficiary groups and the local government institutions (panchayats) – recently set up at three levels in each district, as constitutionally mandated, has to be carefully worked out;

2. Panchayats functioning like clones of the state government and/or over-politicised, vitiate the atmosphere needed for cohesive community involvement ;

3. Equitable sharing of costs and benefits is a difficult objective to achieve but has to be worked out and all sections should have faith in the arrangements and confidence that they will be faithfully followed ;

4. Special arrangements for benefits to the landless (who may contribute through their labour) through access to common land and benefits therefrom will be necessary ;

5. The dilemma of choosing the appropriate technology arises at least after the first simple phase is over. Voluntary Organisations (VO) are more successful in dealing with social issues, but not all are equipped to deal with the technical problems. The traditional knowledge of the people can be neither ignored nor romanticised. Perhaps, the only solution is experimentation and trial and error method. This may involve unintended costs, which have to be borne.

6. The success of the projects depends a great deal on the quality of leadership. Under dedicated and competent leaders, who work for the good of the community, the people are willing to come together, co-operate and even sacrifice. There are examples of decline after change of leadership. The replicability of projects of VOs/people is found to be difficult because of absence dedicated leadership.

6.4 Suggested Direction of Future Efforts

After careful consideration of the past experience and the lessons, we believe that a major reformulation of priorities and programmes and restructuring of institutions and operational means are vital for integrated local watershed development. The following should be the future direction of our efforts:

1. While every effort should be made to complete the on-going major projects within a reasonable time-frame, and urban water needs have to be dealt with urgently, due importance should be given to local water planning, with the ultimate aim of making each rural area manage its own water needs as far as possible, through water-harvesting and conservation measures. The thrust should be towards bringing about a vast number of local initiatives.

2. Such planning, which is the responsibility of District Planning Committees (DPC) and local governments under Part IX of the Constitution of India dealing with Panchayats, should bring out thousands of location – specific water management programmes. Starting initially with the restoration of defunct systems and the adoption of traditional systems, the activities will, over the years, become more and more sophisticated, durable and cost-effective.

3. At every stage, from the very beginning, the people concerned should be involved in working out the plan. It shall be the duty of the DPCs to ensure this, before approving any project. The components of a project would depend on the degree of acceptance by the community concerned and not just the official panchayat. There should be no forced or assumed acceptance.

4. Depending on the degree of social cohesion, the public spiritedness of the panchayats as may be assessed during (3) above, and the availability of leaders or activists in voluntary organisations, the departmental and people's responsibilities may be divided in each project.

5. While local data should be collected by the DPCs through trained volunteers and other means, governments should arrange to provide remote-sensing data to increasing scale, in co-operation with NRSA. A data base should be established and constantly updated at the district level.

6. The DPCs should suggest in each case the relative roles of the panchayats, the concerned beneficiaries and the voluntary organisations. A uniform pattern may not be workable even within the same district or even in one place at all periods.

7. There are exciting possibilities of creative combination of traditional systems, materials and skills with those of modern technology. Exclusive reliance on one or other will not achieve the objectives. State Government should establish technical bodies on the lines of Nirmiti Kendras for constant interactive relationships with the programmes and the people. It should be a two-way relationship.

8. The integrated project should have a carefully worked out and mutually accepted sharing of costs and benefits and arrangements for its faithful implementation. The special requirements of landless, women and other disadvantaged groups should find a place in the arrangements so made. There is no single, uniform pattern of sharing. There are several models and there is great scope for further innovation.

9. The role of Central and State Governments should be to lay down the objectives of the programme and the broad essentials, to integrate the present schemes into one umbrella programme, to restructure the funding arrangements and departmental personnel suitably, in addition to the important functions of data collection, training, research studies, evaluation and dissemination of findings as well as of experience in different states and regions.

10. The Government of India should bring together all the area programmes of different Ministries as well as the rural employment and development programmes into one 'integrated rural area programme' (IRAP). For each eco-system-arid, semi-arid, dry-sub-humid, hill, wastelands, wetlands, heavy rainfall regions, irrigated plains – different location –specific programmes will be drawn up locally under this overall programme. All the existing programmes have to be merged into this and should not continue on parallel lines. New schemes should not also be added on an ad-hoc basis.

11. Integrated watershed development programme (IWDMP) will be an integral part of the IRAP in all areas. The details will vary from place to place, but the minimum components everywhere will be water conservation, soil conservation and greening through people's involvement. At the Central level, the responsibilities for IWDMP should be that of the Ministry of Water Resources.

12. The available resources for all the existing programmes (to be merged) should be pooled together as the fund for the IRAP. It should be distributed districtwise on the basis of criteria to be laid down by the NDC. The DPC shall sanction projects within the outlays so allotted.

13. At least one-third of the available funds for IRAP should be earmarked in each district for IWDMP. The percentage could be higher initially in certain areas.

14. In the districts, the personnel dealing with Area Programmes as well as those dealing with soil conservation, minor irrigation, social forestry and related subjects, as may be appropriate, should be brought into the one inter-disciplinary agency, which will replace the existing DRDA etc. This agency will service the DPC on the one hand by giving inputs for planning and for approval of projects ; and on the other, will be the implementing arm of the District and lower panchayats and increasingly function as "supporting services" for the people's organisations and community efforts.

The future direction of efforts suggested by us will involve radical changes in approaches and attitudes and in methods of funding and implementation. It would not, therefore, be easy to get it accepted. In particular, the changes needed in the departmental hierarchies in the states are so fundamental that they will be strongly resisted, as has happened from the days of community development. We are convinced, however, that such changes are vital both for the success of democratic decentralisation under implementation since the constitutional amendments of 1992 and for all rural area development programmes, including the proposed high-priority IWDMP.

CHAPTER - 7

INTER-BASIN TRANSFERS

There are large disparities in the availability of water between different river basins. Per capita utilisable water availability based on 1991 population varies from 182 m^3 in Sabarmati basin to 2,500 m^3 in Mahanadi and 3,082 m^3 in Narmada basins. Utilisable water availability per ha of culturable area varies from 1,244 m^3 per ha in Sabarmati basin to 8,320 m^3 per ha in Mahanadi and 7,669 m^3 per ha in Narmada basins. In view of these disparities in different river basins of India, inter-basin transfer of water has been receiving attention from Indian water resource planners. There is a specific term of reference to the Commission pertaining to inter-basin transfer of water, namely "To suggest modalities for transfer of surplus water to water deficit basins by interlinking of rivers for achieving the above objectives".

In this Chapter, the need and the problems of inter-basin water transfer have been examined. The detailed water balance studies have had to be limited to Peninsular rivers as the data for Himalayan rivers were not available.

7.1 Historical Perspective

Lt. Gen. Sir Arthur Cotton pioneered development of water resources in southern India from 1839 onwards. He developed a plan to interlink Indian rivers for inland navigation. The plan was partially implemented but later got abandoned as railways got priority.

Based on some earlier work in Central Water Commission, Dr. K.L. Rao proposed a National Water Grid for providing navigation and ameliorating spatial disparities between different river basins. His plan envisaged a Ganga-Cauvery link off-taking near Patna and passing *en route* through the basins of Sone, Narmada, Tapi, Godavari, Krishna and Pennar ultimately joining Cauvery upstream of the Grand Anicut (Fig. 7.1). The 2,640 Km long link involved withdrawal of 1,680 m^3/s (60,000 cusecs) of flood flows in Ganga for about 150 days in the year. Out of this, 1,400 m^3/s (50,000 cusecs) was to be pumped over a head of 450 m for transfer to the Peninsular region and the balance utilised within the Ganga basin itself. The proposal aimed at utilisation of 2.59 Mham of Ganga waters to irrigate an additional area of 4 Mha. Later, detailed examination showed that the proposal was very costly and lower cost alternatives were available. Dr. Rao had also proposed a few additional links which were not pursued.

Captain Dastur, an air pilot, proposed an impressionistic scheme which became known as the Garland Canal scheme. His scheme was *prima facie* impractical but persisted for some time as it caught the imagination of a number of persons.

The work of interlinking of river basins does not involve technological problems of a radically different nature from other major water resource projects and is well within the capability of Indian Engineering. In fact, several such schemes exist and are functioning in the country. Examples are Periyar –Vaigai Project, Parambkulam Aliyar Project, Kurnool-Cudappa Canal and the recent Telugu Ganga Project. The inter sub-basin transfers in the Indus Basin from Ravi to Beas, and Beas to Sutlej have tackled difficult design and construction problems. Narmada Main Canal, one of the largest in the world, would convey Narmada waters across many major streams. It is undoubtedly a mega inter-basin transfer project and cross drainage works of unprecedented magnitude have been designed and are under construction.

FIG 7.1 : DR. K.L. RAO'S PROPOSAL

The present efforts in this matter are based on the National Perspective on which a great deal of work has been done by the National Water Development Agency.

Typical Large Scale Inter-basin Transfers in North America

S.No.	Contributing Basin/Region	Receiving Basin/Region	Average Annual Transfer	Major Purpose
1	**2**	**3**	**4**	**5**
1	Eastmain-Opinaca	La Grande	798	Hydro
2	Caniapiscau	La Grande	771	Hydro
3	Churchill (Southern Indian Lake)	Rat-Burntwood	752	Hydro
4	Naskaupi Kanairiktok	Churchill	330	Hydro
5	Lake Erie	Lake Ontario	250	Hydro
6	North California	San Jaoquin Valley,Southern California	121	Irrigation, Municipal & industrial

7.2 National Perspective

A National Perspective for Water Development was framed in August, 1980 by the Ministry of Water Resources. It was discussed at various governmental levels and a National Water Development Agency was set up in 1982 to carry out detailed studies in the context of the National Perspective. Considerable work has been done and the National Perspective has been developed in fair detail. On the basis of these studies, the proposal is briefly reviewed here.

The basic aim is to utilise all the possible utilisable waters. For this purpose, creation of storages and interbasin transfers from the surmised surplus river basins to deficit basins has been the guiding objective. An argument of integrating the rivers contributing to national integration has also been advanced. It has been considered that population would be stabilised by 2050 AD and that self sufficiency in food can be achieved only by utilising the water otherwise going to waste in the surplus river basins. On this basis, it is considered imperative that all the rivers in the country be linked by a national grid to meet the shortages in the various parts of the country (IWRS, 1996). No socio-economic criteria appear to have been laid down for evaluating the proposals.

The broad approach adopted in the National Perspective is as follows (NWDA, 1998):

- Existing uses have to be kept undisturbed.
- Normally water development under the existing legal and constitutional framework is assumed to take place fully by the turn of the century.
- The development envisaged is within the framework of all the existing agreements between the states.

- While planning inter-basin and inter-state transfer of water, reasonable needs of the basin states for the foreseeable future have to be kept in view and provided for.

- Most efficient use of land and water in the existing irrigation and hydro power stations should be a principal objective to be achieved.

The National Perspective brought out by the Ministry of Water Resources has two main components, (a) Himalayan Rivers Development and (b) Peninsular Rivers Development. The Himalayan Rivers Development envisages construction of storage reservoirs on the principal tributaries of Ganga and the Brahmaputra in India and Nepal along with interlinking canals systems to transfer surplus flows of the eastern tributaries of the Ganga to the west, apart from linking of the main Brahmputra and its tributaries with Ganga and Ganga with Mahanadi (Fig.7.2). Peninsular component is divided into four major parts (Fig. 7.3) :

(i) Interlinking of Mahanadi- Godavari – Krishana – Cauvery rivers,

(ii) Interlinking of west flowing rivers north of Bombay and south of Tapi,

(iii) Interlinking of Ken-Chambal and

(iv) Diversion of other west flowing rivers.

These links will involve stupendous engineering activity. They will have large scale socio-economic, human and environmental impacts and will involve very high financial outlays. It is, therefore, necessary to closely examine the objectives and evaluation criteria. Before inter basin transfers are taken up, basin wise surplus and shortage of water resources have to be established. Legitimate projected demands of the surplus states will have to be met in future. Some of the pre-feasibility studies indicate requirements of storage, construction of large capacity canals, numerous major cross drainage works etc. Proposed inter basin links will require studies involving technical feasibility, economic viability, legal framework, socio-environmental impacts and large financial resources.

There will be opposition from the local people especially those who consider themselves deprived and from environmental agencies and activists unless their legitimate concerns are looked into. Above all, there will be the human problem of displacement of people and their rehabilitation. There is urgent need to develop a policy and programme of sustainable water resource development of each river basin in which inter basin transfer, if found feasible, would be one possible component.

7.3 Studies by NWDA

In addition to surveys and investigations of possible storage sites and interconnecting links in order to establish feasibility of proposals forming part of the National Perspective, NWDA was also to assess the quantum of water which could be transferred to other basins/ states after meeting reasonable needs of the basin states and to prepare feasibility reports of the various components. NWDA has completed water balance studies of 137 basins/sub-basins and 71 diversion points and has prepared pre-feasibility reports of 31 links (17 in Peninsular component and 14 in Himalayan component). These feasibility reports of Peninsular links do not include some of the links proposed by the National Perspective as they are not considered feasible. The sixteen Peninsular links being studied by NWDA are shown in Fig. 7.4. In the Himalayan component also, NWDA has reduced the number of links envisaged in the National Perspective. The fourteen Himalayan links taken up for study by NWDA are shown in Fig.7.5. Some of the important links in the Himalayan component are as follows :

FIG 7.2: HIMALAYAN RIVERS DEVELOPMENT COMPONENT

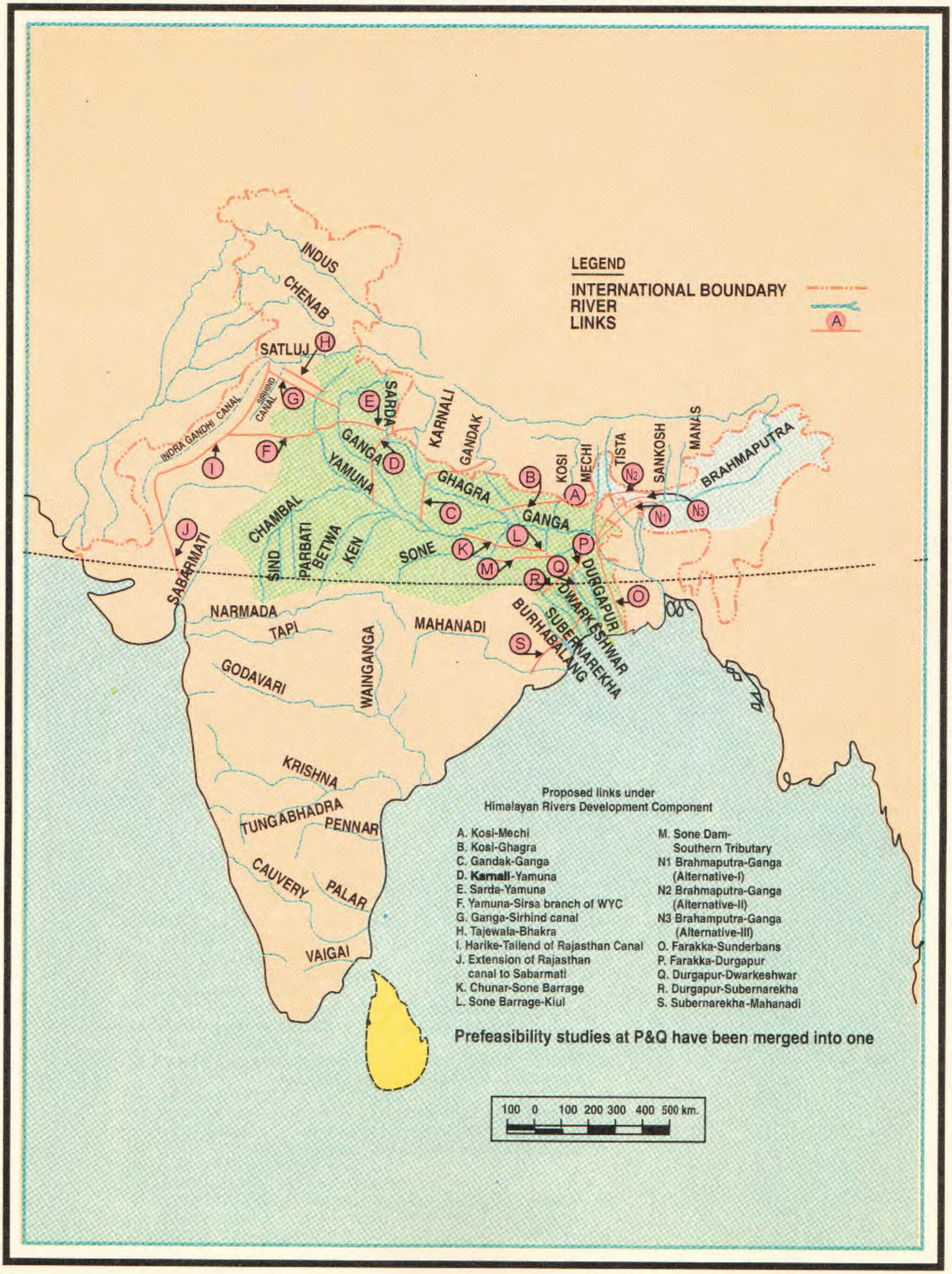
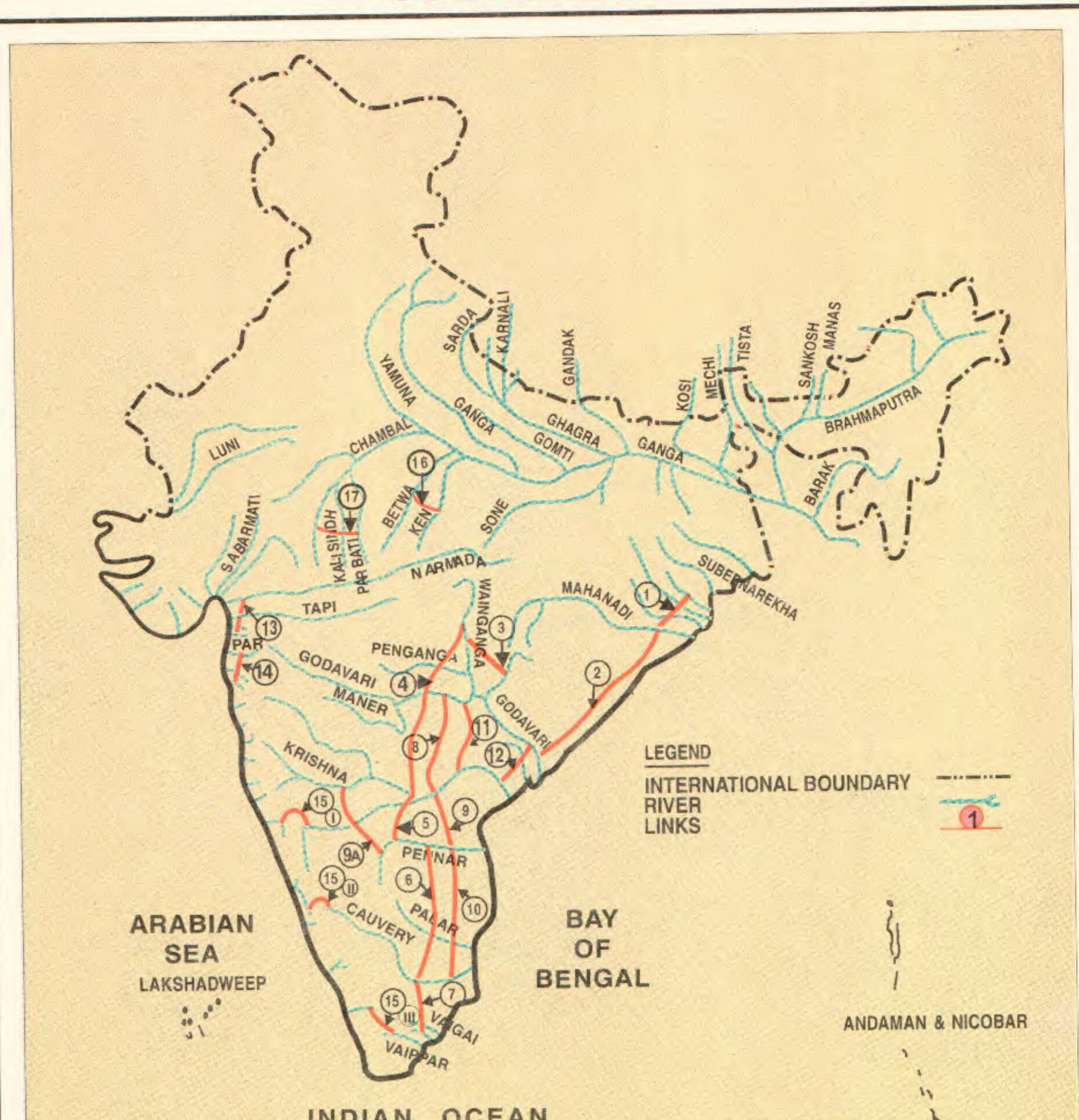


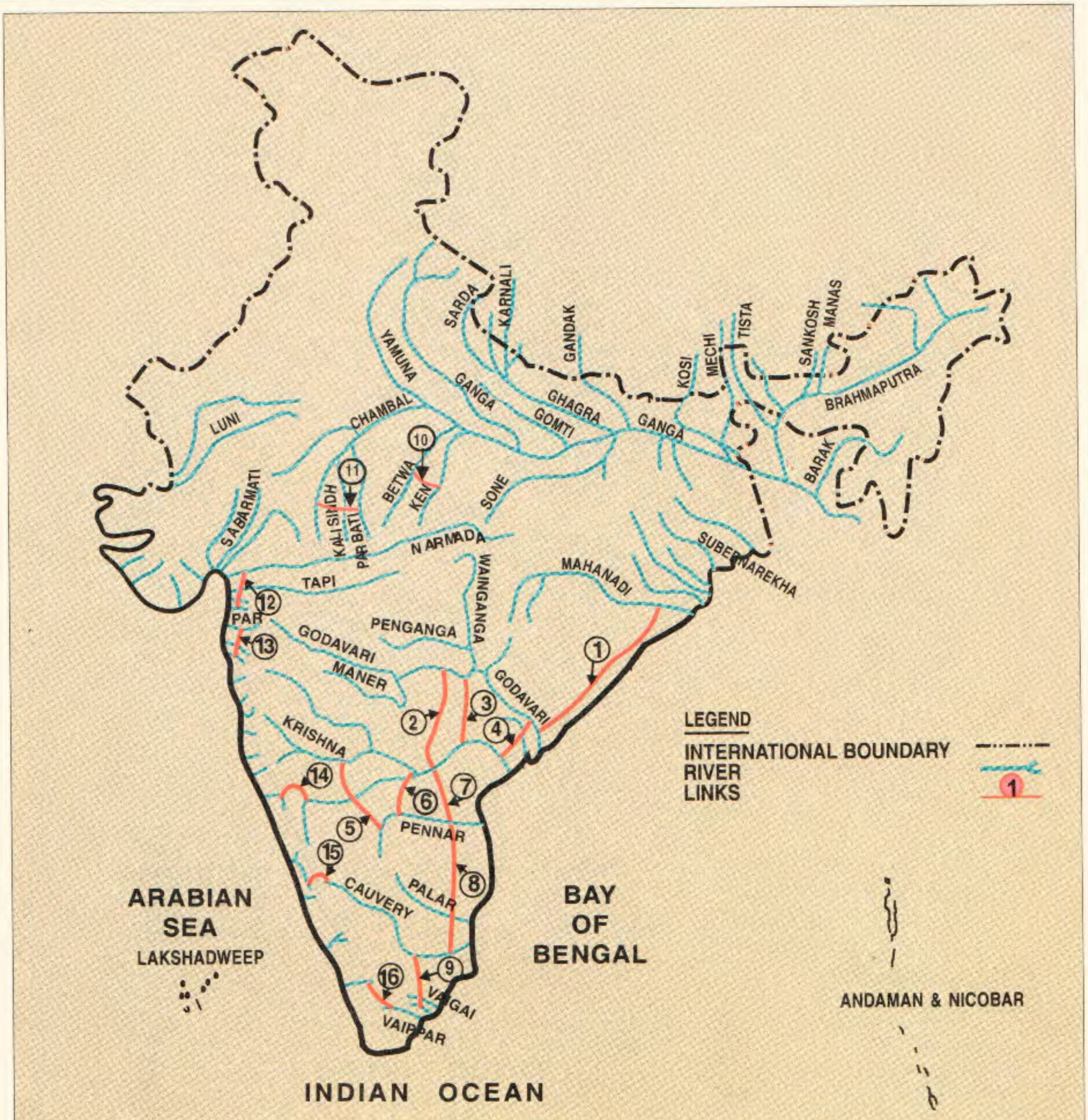
FIG 7.3 : THE PENINSULAR RIVERS DEVELOPMENT COMPONENT



PENINSULAR RIVERS DEVELOPMENT COMPONENT

1 MAHANADI - BURHABALANG
2 MAHANADI - GODAVARI
3 INDRAVATI - WAINGANGA
4 WAINGANGA - KRISHNA
5 KRISHNA (SRISAILAM) - PENNAR (PRODATTUR)
6 PENNAR (GANDIKOTTA) - PALAR - CAUVERY
7 CAUVERY - VAIGAI
8 GODAVARI (INCHAMPALLI) - KRISHNA (NAGARJUNASAGAR)
9 KRISHNA (NAGARJUNASAGAR) - PENNAR (SOMASILA)
9A KRISHNA (ALMATTI) - PENNAR
10 PENNAR (SOMASILA) -PALAR - CAUVERY (COLEROON)
11 GODAVARI (INCHAMPALLI) - KRISHNA (PULICHINTALA)
12 GODAVARI (POLAVARAM) - KRISHNA (VIJAYAWADA)
13 PAR - TAPI - NARMADA
14 DAMANGANGA - TANSA / PINJAL
15 WEST FLOWING RIVERS OF KERALA AND KARNATAKA (WEST - EAST LINK)
(I) BEDTI - VARDA
(II) NETRAVATI - HEMAVATI
(III) PAMBA - ACHANKOVIL - VAIPPAR
16 KEN - BETWA
17 PARBATI - KALISINDH - CHAMBAL

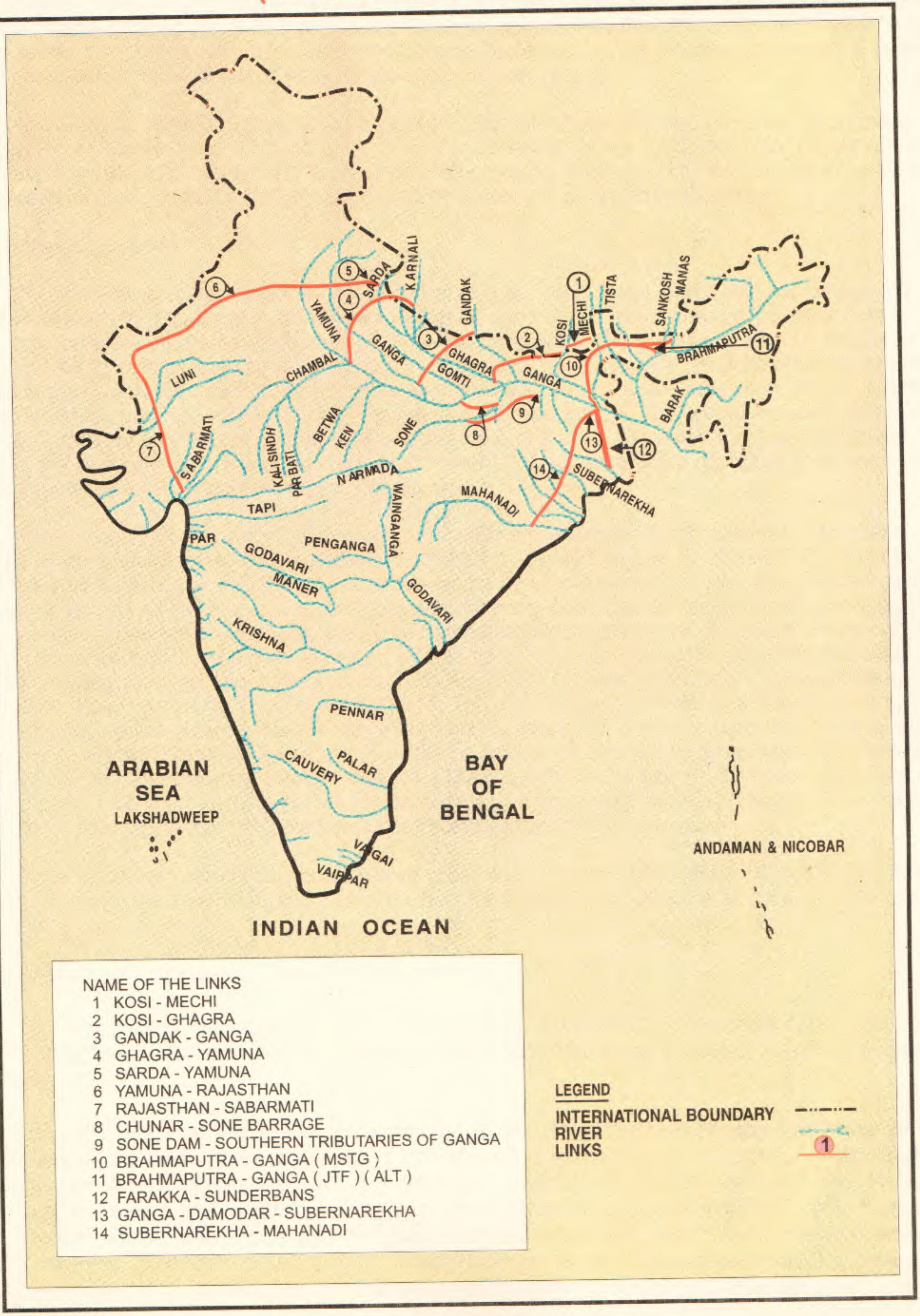
FIG 7.4 : PROPOSED LINKS UNDER STUDY
(PENINSULAR COMPONENT)



NAME OF THE LINKS

1 MAHANADI (MANIBHADRA) - GODAVARI (DOWLAISWARAM)
2 GODAVARI (INCHAMPALLI) - KRISHNA (NAGARJUNASAGAR)
3 GODAVARI (INCHAMPALLI LOW DAM) - KRISHNA (NAGARJUNASAGAR TAIL POND)
4 GODAVARI (POLAVARAM) - KRISHNA (VIJAYAWADA)
5 KRISHNA (ALMATTI) - PENNAR
6 KRISHNA (SRISAILAM) - PENNAR
7 KRISHNA (NAGARJUNASAGAR) - PENNAR (SOMASILA)
8 PENNAR (SOMASILA) - CAUVERY (GRAND ANICUT)
9 CAUVERY (KATTALAI) - VAIGAI - GUNDAR
10 KEN - BETWA
11 PARBATI - KALISINDH - CHAMBAL
12 PAR - TAPI - NARMADA
13 DAMANGANGA - PINJAL
14 BEDTI - VARDA
15 NETRAVATI - HEMAVATI
16 PAMBA - ACHANKOVIL - VAIPPAR

FIG 7.5 : PROPOSED LINKS UNDER STUDY (HIMALAYAN COMPONENT)



Manas – Sankosh – Teesta – Ganga (Farakka) link canal envisages diversion of surplus waters from Manas and Sankosh rivers in Brahmaputra Basin for augmenting flows of Ganga at Farakka. A link to Peninsular component through Subernarekha and Mahanadi is also envisaged enabling further transfer to water short basins of Krishna, Pennar and Cauvery rivers.

Kosi-Ghagra, Gandak-Ganga, Ghagra-Yamuna, Sarda-Yamuna links are proposed to supplement the supplies of Ganga and Yamuna and to further transfer water westwards to Rajasthan and Sabarmati. A large canal parallel and to the east of the existing Rajasthan canal is proposed which will be extended beyond the tail of the present Rajasthan canal and be linked to Sabarmati.

7.4 Basic Approach

In approaching this complex issue, we begin with the assessment that it will not be possible to persuade a state to spare water till its own demands are met to the maximum possible extent. In basins with possible surpluses, near saturation utilisation of land and water has first to be aimed at subject to the condition that such utilisation is not based on impractical engineering, for example storage requirements for which reservoir sites are not available or involve very high lifts or wasteful use, for example, very low efficiency and excessive water application. This would include first priority domestic, industrial and environmental uses and then irrigation use. Provision must also be made for minimum flows during lean season to meet environmental requirements for maintaining water quality and for customary use by people living on river banks.

After meeting all these essential requirements, if there is surplus water available in the basin, its transfer to other basins may be considered. Such basins should first aim at efficient utilisation of all the in-basin resources. For deficit basins, the aim would be to meet domestic and industrial demand in full, but to achieve a lower cropping and irrigation intensity than that in case of well – endowed or surplus basins. The overall approach should be that economic development of no part of the country should be constrained by shortage of water, at the same time the pattern of development could be different in states having adequate water and those to which water may have to be transferred at high cost. Food self sufficiency is essential for the country as a whole but not necessarily for individual river basins. Nevertheless, it has to be borne in mind that even in a basin not endowed with ample water resources, almost two – thirds of the population is dependent on agriculture, and sharp reduction in their numbers may not be feasible. Their quality of life can be improved only through increased agricultural productivity for which the first basic requirement is water. Hence, in all basins of peninsular rivers, the present irrigated area has to be substantially increased.

Based on these considerations, we have worked out the water availability, projected demand of various sectors in the year 2050 and the water balance for six of the major east flowing rivers of the peninsula.

7.5 Review of Inter-basin Transfer Proposals

The Commission has reviewed and done work only on Peninsular component for Inter-basin Transfer Proposals. Unfortunately, the Himalayan component data being classified, were not available for analysis.

Generally speaking, the idea is to transfer water from water rich Brahmaputra and lower Ganga basins towards the west, finally conveying it to water·short southern U.P., Haryana, Punjab and to arid Rajasthan desert, as also perhaps to the Peninsular component. The storages and links involved are of very large sizes and lengths; and the costs of construction and environmental problems would be enormous. These links should only be taken up if and when they are considered unavoidable in national interest. For Thar desert area, it would perhaps be desirable to promote arid zone low density tree cover as far as possible. The Indira Gandhi Nahar on the west and Narmada canal on the south east, together with practices of desert moisture conservation can perhaps achieve this limited objective. The need for further expansion of irrigation facilities in this area will have to be examined from all angles including ecological & environmental considerations.

On the basis of published information, the Commission is of the view that the Himalayan component would require more detailed study using system analysis techniques. Actual implementation is unlikely to be undertaken in the immediate coming decades.

East Flowing Rivers

Nine links are proposed for inter-linking East flowing peninsular rivers. The details of the proposed links are given in Table 7.1. These linkages pre-suppose the construction of five dams. Apart from the problems of submergence and rehabilitation, these links will also require agreements between all the concerned states. Irrespective of present or future constitutional provisions, it would not be practical to transfer water without concurrence of the donor states and such concurrence would be facilitated by some form of *quid pro quo.*

Water Balance Studies

Water Balances have been prepared for six East flowing rivers which are involved in the nine links to determine the extent of deficit or surplus for planning inter-basin transfer. For each of these basins, mean annual flow, 75 percent dependable flow, utilisable surface water and replenishable ground water are given by CWC, NWDA and CGWB (Chapter – 3). Conceptually, the sum of utilisable surface water and replenishment to ground water should not exceed mean annual flow. However, in all basins except Mahanadi, the sum of the estimated utilisable surface water and replenishable ground water does exceed the mean annual flow. This may be due to many assumptions involved in the estimated value of utilisable surface water, replenishable ground water and the mean annual flows. For working out water balances, the replenishable ground water has been reduced by one – third to take into account direct flow into the sea, possible direct evapo – transpiration from low lying areas and possibility of some uncertainty in estimation of replenishable ground water in hard rock areas. Utilisable total water was thus taken to be the sum of the utilisable surface water and two – thirds of replenishable ground water. In the case of Pennar, Cauvery and Vaigai basins, the sum of utilisable surface water and two – thirds of ground water exceeds the mean annual flow in the respective rivers. In these cases, the water availability has been limited to mean annual flow.

The CWC estimated the basinwise mean annual flow from the observed flows corrected for the abstraction upstream of the points of flow measurement, assumed certain return flows and evaporation from reservoirs to get the natural flows. In these estimates, the CWC assumed 10 percent return flow from surface water diversion (neglecting Ground Water return flow) which is on the low side. Lower assumed value of return flow would result in higher value of computed mean flow. With the present irrigation water use and efficiencies, the return flow would be of the order of 30 percent to 40 percent or higher depending on paddy intensity. The change in assumed return flows will reduce the mean flows significantly in basins where present utilisation level is high such as Krishna, Pennar, Cauvery and the East flowing rivers south of Pennar. It has been estimated that the annual surface potential would reduce by 10 percent to 15 percent, and correspondingly the balances worked out will be lower to that extent.

Table - 7.1
Details of Proposed Links

S. No.	Name of the Link	Connecting Rivers		FSL at Head	FSL at Tail	Length	Discharge	Annual Volume Transfer	Enroute Irrigation Vol. Mm^3	Losses
				m	m	km	m^3/Sec.	Mm^3	Area ha.	Mm^3
1	2	3	4	5	6	7	8	9	10	11
1	Manibhadra to Dowlaiswaram	Mahanadi	Godavari	74	13.81	932	627	11,176	3,854	822
								6,500	4,54,229	
2	Inchampalli to Nagarjunasagar	Godavari	Krishna	142	182.77	299	1219	16,426	1,850	376
								14,200	3,19,708	
3	Inchampalli to Pulichintala	Godavari	Krishna	106.68	69.68	270	263	4,371	4,221	150
								-	6,94,882	
4	Polavaram to Vijaywada	Godavari	Krishna	40.232	27.965	174	361	4,903	1,448	150
								3,305	1,48,418	
5	Almatti-Pennar	Krishna	Pennar	510	434.4	564	208.12	1,980	1,778	202
								-	2,34,589	
6	Srisailam-Pennar	Krishna	Pennar	268.15	156.51	171.3	186	2,310	-	215
								2,095		
7	Nagarjunasagar-Somasila	Krishna	Pennar	151.67	102.63	394	555	12,146	3,166	332
								8,648	5,60,606	
8	Somasila-Grand Anicut	Pennar	Cauvery	91.96	59.7	538	616.4	8,565	3,170	385
								3,855	4,91,200	
9	Kattalai Regulator-Vaigai-Gundar	Cauvery	Vaigai	100.75	78.865	250	174.14	2,252	2,007	136
							29.88	-	3,53,337	

Note: *(1) In col. 9, the upper figure indicates the gross diversion while the lower gives the quanitity reaching the recipient river. The difference is accounted for the enroute irrigation and losses.*
(2) In col. 10, the upper figures are volume used enroute and the lower figures are area irrigated enroute.

Gross Water Demand

Gross water demand for domestic, industrial, energy, ecology and navigation purposes and estimated lake/reservoir evaporation losses in the year 2050 have also been worked out as per norms given in Chapter – 3. 70 percent of the demand for urban and 30 percent for the rural area are assumed to be met from surface water. 70 percent of the industrial and 80 percent of the energy demand are taken as met from surface water.

Water requirement for irrigation in the year 2050, for the six Peninsular river basins has been worked out on the basis of following assumptions:

(i) Cropping intensity of 120 to 130 percent of culturable area is taken which would vary between 160 to 185 percent of present net sown area. Irrigation intensity is kept not less than 30/40 percent of the gross sown area. In all cases the present irrigation area is increased substantially.

(ii) Irrigation water requirement for the crops has been worked out assuming overall efficiency of 60 percent and 75 percent for surface and ground water respectively. These values of efficiency are envisaged for the year 2050. The present available efficiency is in the range of 30 percent to 50 percent for surface water irrigation. Sustained effort will be needed on the conveyance system and on farm water application to bring about the improved efficiency. NWDA has worked out average irrigation water depth based on project reports for the existing and on-going projects and on climatological approach for the future projects. Average Net Irrigation Requirement (NIR) and Gross Irrigation Requirement (GIR) (inclusive of conveyance losses) are worked out for the cropping pattern likely to be adopted in the area including deep percolation from paddy fields. Average NIR and GIR are computed for each sub-basin and the values are given in Annexure 7.1 and average basin values of GIR are given in the Table 7.2. It is seen that the average values of GIR for surface water vary between 0.56 and 0.96 m. The average values of GIR for ground water vary between 0.45 and 0.77m. The minimum values are obtained in Godavari basin and maximum values are obtained in Cauvery basin.

Return Flow

Return flow from the domestic water supply and industrial demand has been taken as 50 percent. 85 percent of the return flow from domestic supply is assumed to accrue to surface water and the remaining will go to ground water, whereas entire return flow from industrial use is assumed to be returned to surface water.

Return flow from irrigation is worked out from the difference between GIR including deep percolation and NIR excluding deep percolation (consumptive use – effective rainfall) i.e.

Return Flow = C [GIR-{ET_C- Eff Rainfall}]

in which GIR is gross irrigation requirement including percolation losses, ET_C is crop water requirement and factor C takes care of losses.

It is assumed that 15 percent of such 'difference' might be lost due to evaporation/evapo-transpiration from swamps and water logged areas and 5 percent may be lost to sea. Therefore, 80 percent of the 'difference' is taken to return to the system i.e the value of C = 0.8 (Table 7.2). Average return flow ranges between 46 and 60 percent for surface water and between 38 and 55 percent of ground water. The lower values are obtained in Krishna basin and higher values in Mahanadi basin. The percentage of return flows obtained is larger than that usually presumed. One reason is predominant paddy cropping with high infiltration to ground water. However, comparative water balance figures assuming return flow to be 60 percent rather than 80 percent of the 'difference' have also been worked out and are shown in Table 7.2. In this case, the average return flow ranges between 35 and 45 percent for surface water and between 28 and 41 percent for ground water.

90 percent of the return flow from irrigation is assumed to reach ground water reservoir and remaining into the streams.

Table - 7.2
Average Gross Irrigation Water Requirement and Return Flow

Basin	Average NIR in Metres	Average Gross Irrigation Water Required in Metres		Return Flow in Percent			
				0.8(GIR-NIR)		0.6(GIR-NIR)	
		SW	GW	SW	GW	SW	GW
Mahanadi	0.167	0.67	0.54	60.1	55.1	45.1	41.3
Godavari	0.200	0.56	0.45	51.4	44.2	38.5	33.1
Krishna	0.250	0.60	0.48	46.7	38.3	35.0	28.7
Pennar	0.290	0.75	0.60	49.1	41.2	36.8	30.9
Cauvery	0.380	0.96	0.77	48.3	40.5	36.2	30.3
Vaigai	0.300	0.89	0.71	53.0	45.8	39.5	34 .7

Environmental releases, navigational requirement and evaporation losses from the lakes/reservoirs are taken from basinwise water balance studies given in Chapter 3.

Water balances of Mahanadi, Godavari basin, Godavari at Inchampalli, Krishna, Pennar, Cauvery and Vaigai are given in Annexure 7.2. Abstract of the water balances as per both the assumptions mentioned above is given in Tables 7.3 (a) and (b). Balances of these basins are computed from the water availability, gross water demands for domestic, industrial and energy uses, evaporation losses from lakes/reservoirs, ecological releases, irrigation water requirement and return flow from domestic, industrial, energy and irrigation water uses. Water balances also take into account imports from and exports to other basins, existing, or under execution. Balances are given for the mean annual flow and 75 percent dependable flow. The mean annual flow encompasses utilisable surface water and replenishable ground water. Hence, it is backed by surface storages and also by underground water reservoir. It is, therefore, considered that the balances worked out on the basis of mean annual flow present a more realistic picture. The balances based on 75 percent dependability would be extremely conservative.

In working out the water balance in Chapter 3, our approach was from demand side, that is, to work out the food requirement for the projected population followed by irrigated area needed to produce that quantity of food and hence the quantum of water required. The water demand for other sectors was also worked out on similar lines. The sum of the utilisable surface water and replenishable ground water is taken as the total availability. In this chapter, water availability is taken as sum of the utilisable surface water and two-thirds of the replenishable ground water as explained earlier. In basins, where sum of the utilisable surface water and two-thirds of the replenishable ground water exceeds mean annual flow, the availability is limited to the mean annual flow. Irrigation water requirement is worked out for the proposed irrigation area based on the existing, on-going and proposed projects subject to a minimum irrigation intensity of 30 to 40 percent of the proposed gross sown area. However, the difference in the two water balances is not significant.

It will be seen from Tables 7.3 (a) and (b) that based on mean annual flows except for Krishna (if irrigation intensity is adopted at a rather high 45 percent), Cauvery and Vaigai, the balances are positive in other cases. The shortage in Cauvery is 12 percent of gross demand and that in Vaigai 16 percent. These shortages result after increasing the present irrigated area to 1.4 times in case of Cauvery and 1.6 times in case of Vaigai and assuming the return flow at 60 percent of the 'difference'. In case the return flow is taken as 80 percent, there is no shortage in Krishna and those in Cauvery and Vaigai are reduced to 5 percent and 8 percent respectively. Thus, there seems to be no imperative necessity for massive water transfers. The assessed needs of the basins could be met from full development and efficient utilisation of intra-basin resources except in the case of Cauvery and Vaigai basins. Therefore, it is felt that limited water transfer from Godavari at Inchampalli and Polavaram towards the South would take care of the deficit in Cauvery and Vaigai basins, make more optimal use of water and also improve river ecology. Some of the transfer may be achievable by gravity, and rest by pumping to practicable heights. Efforts should be made to utilise existing links like Telugu Ganga as far as possible. Though surplus is available in Mahanadi also, the transfer from that river would require much longer link and is in any case not required for the immediate future as the projected shortages could be met from Godavari itself.

Although the present studies indicate the need for only limited transfer from Godavari towards the South, the Commission would like to stress the limitations of these studies. The possibility of the mean flows, as assumed in the present study, being overestimated has been brought out earlier. Also, the deficit and marginally surplus basins may require maintenance of higher flows than those adopted in the downstream reaches, estuaries and deltas in the lean season. The possibility of using 80 percent of the difference between GIR and NIR for irrigation has also been questioned, since it may involve lifts from lower reaches. Accordingly, balances have also been worked out on the basis of 60 percent use of the 'difference'. There are some uncertainties about the ground water estimation also. In view of these limitations and uncertainties, the Commission is of the view that further studies as to the future possibilities of interbasin transfer in the east flowing rivers, need to be continued.

Water availability and culturable area are not spread evenly in the vast basins of Mahanadi, Godavari and Krishna. Consequently, water balance situation is not uniform. For getting a more realistic picture, water balance should be prepared at various locations of the large river basins. Water available upstream of Sriramsagar Project on Godavari is not sufficient to bring the available culturable area under irrigation. The yield available below Sriramsagar project gives rise to sizeable surplus after meeting the demand of the lower reaches. Such surplus cannot be utilised for irrigating areas in the upper reaches as it involves lifts exceeding 300 m.

It may be pointed out that Orissa and Andhra Pradesh have claimed that all the waters of Mahanadi and Godavari could be utilised within the basins and that there are no surpluses. Leaving aside the legal issues, the Commission is unable to agree with this view. The water balance study (Table 7.3) is based on a several fold increase in irrigated area over and above the present irrigated areas, for example, in the case of Mahanadi, irrigated area increased from 2.02 to 7.617 M ha and in case of Godavari from 4.12 to 14.072 M ha. It is most unrealistic to postulate that technically and economically feasible schemes can be planned to irrigate more areas within the basins.

Table - 7.3 (a)
Statement of Water Resources Balance {Return Flow = 0.6 (GIR-NIR)}

Sl. No.	Basin	Water Availability				Proposed GSA	Present Irrigation	Proposed Irrigation	Percent of GSA	Gross Water Demand			Return Flow			Balance	
		Mean Annual Flow	75% Dependable Flow	*Total Utilisable Water	Import/ Export					Non Agricu.	Irrigation	Total	Non Agricu.	Irrigation	Total	Mean Annual Flow	75% Depe. Flow
		Mm^3	Mm^3	Mm^3	Mm^3	M ha	M ha	M ha	Percent	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Mahanadi Basin	66880	53780	61000	-1049	10.882	2.02	6.430	59.1	15110	38531	53,641	3268	16659	19,927	32118	19018
								7.617	70.0	15110	45854	60,964	3268	19859	23,127	27995	14895
2	Godavari Basin	110540	80550	103367	-17359	23.453	4.12	9.604	40.9	28827	47732	76,559	6789	17113	23,902	40525	10535
								14.072	60.0	28827	69926	98,753	6789	25067	31,856	26285	-3705
3	Godavari at	76185	66193	68583	-750	12.016	1.132	5.665	47.1	14937	27693	42,630	3786	9815	13,601	46408	36416
	Inchampalli @							7.210	60.0	14937	35745	50,682	3786	12793	16,580	41333	31341
4	Krishna	☆ 69810	60140	75600	-8290	25.082	3.88	7.530	30.0	29846	40980	70,826	7059	13301	20,361	11055	1385
								11.290	45.0	29846	61644	91,490	7059	20064	27,123	-2847	-12517
5	Pennar	6320	4390	10147	2893	3.642	0.99	1.093	30.0	4415	7148	11,563	1214	2387	3,601	1251	-679
								1.350	37.1	4415	9075	13,490	1214	3096	4,310	33	-1897
6	Cauvery	21360	19370	27200	-1392	6.791	1.92	2.717	40.0	11984	23043	35,027	3139	7638	10,777	-4281	11
7	Vaigai	670	505	1235	341	0.574	0.108	0.172	30.0	829	1306	2,135	310	474	783	-340	-505

* Total utilisable water includes utilsable surface water and 2/3 replenishable ground water.

@ In Lower Godavari Sub-basin, there is deficit of 10,376 Mm3, which has to be released from Inchampalli.

☆ Actual value given by CWC is 78.12 BCM. The figure of 69.81 is as adopted by Krishna Tribunal.

Table - 7.3 (b)
Statement of Water Resources Balance {Return Flow = 0.8 (GIR-NIR)}

Sl. No.	Basin	Water Availability				Proposed GSA	Present Irrigation	Proposed Irrigation	Percent of GSA	Gross Water Demand			Return Flow			Balance	
		Mean Annual Flow	75% Dependable Flow	*Total Utilisable Water	Import/ Export					Non Agricu.	Irrigation	Total	Non Agricu.	Irrigation	Total	Mean Annual Flow	75% Depe. Flow
		Mm^3	Mm^3	Mm^3	Mm^3	M ha	M ha	M ha	Percent	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Mahanadi Basin	66880	53780	61000	-1049	10.882	2.02	6.430	59.1	15110	37972	53,082	3268	21760	25,028	37778	24678
								7.617	70.0	15110	45854	60,964	3268	26478	29,746	34614	21514
2	Godavari Basin	110540	80550	103367	-17359	23.453	4.12	9.604	40.9	28827	47732	76,559	6789	22802	29,591	46214	16224
								14.072	60.0	28827	69926	98,753	6789	31788	38,577	33006	3016
3	Godavari at	76185	66193	68583	-750	12.016	1.132	5.665	47.1	14937	27693	42,630	3786	13079	16,866	49672	39680
	Inchampalli @							7.210	60.0	14937	42834	57,771	3786	20425	24,212	41876	31884
4	Krishna	☆ 69810	60140	75600	-8290	25.082	3.88	7.530	30.0	29846	40980	70,826	7059	17726	24,786	15480	5810
								11.290	45.0	29846	60432	90,278	7059	25766	32,825	4068	-5602
5	Pennar	6320	4390	56537	2893	3.642	0.99	1.093	30.0	4415	7148	11,563	1214	3182	4,396	2047	117
								1.350	37.1	4415	9075	13,490	1214	4128	5,342	1066	-864
6	Cauvery	21360	19370	61450	-1392	6.791	1.92	2.717	40.0	11984	23043	35,027	3139	10169	13,308	-1750	-3740
7	Vaigai	670	505	1235	341	0.574	0.108	0.172	30.0	829	1306	2,135	310	632	941	-182	-347

* Total utilisable water includes utilsable surface water and 2/3 replenishable ground water.

@ In Lower Godavari Sub-basin, there is deficit of 10,376 Mm3, which has to be released from Inchampalli.

☆ Actual value given by CWC is 78.12 BCM The figure of 69.81 is as adopted by Krishna Tribunal

The Godavari Water Disputes Award envisaged construction of a dam at Inchampalli with an inter-state agreement between Andhra Pradesh, Madhya Pradesh and Maharashtra. Andhra Pradesh proposed a high dam to irrigate 1,37,883 ha annually by gravity, 8,173 ha by lift and to generate 2,763 million unit of energy annually. The high dam would submerge an area of 92,555 ha and displace over one lakh people. An alternative has been proposed to build a low dam at Inchampalli with pond level of 95 m to lift water from Godavari to meet the demand of Warangal plateau and to transfer certain quantum (6.31 km^3) of water from Godavari basin to Krishna basin. In view of the magnitude of the human problem involved in rehabilitation, it will be more appropriate to go for a low dam, and utilise about 6.3 km^3 of additional water. This could be used partly in Krishna basin and partly transferred farther to Cauvery and Vaigai. Studies have to be made to find out the optimal quantity of transfer to individual basins and to examine how far the existing links can be utilised to effect such transfers.

West Flowing Rivers North of Mumbai

Par-Tapi-Narmada Link

The proposed Par-Tapi-Narmada link envisages transfer of surplus water from the five west flowing rivers between Par and Tapi to water deficit areas in North Gujarat.

The link proposal consists of seven reservoirs on these rivers and a 400 km long link canal connecting these reservoirs and carrying the water through Ukai reservoir to the target command areas north of Narmada. Taking the entire system, the cost of water delivered is high and can hardly be borne by the farmers at prevailing agricultural prices. The irrigation rates may have to be very heavily subsidised which is not in conformity with current thinking. It is felt that these links should be deferred till the impact of Sardar Sarovar Project is seen and the need for additional supplies clearly established. However, Phase I of the Project transferring surplus water from Ukai reservoir could prove beneficial provided that, with the projected consumption based on increased population and demand, there is still a reasonable surplus at Ukai.

Damanganga-Pinjal Link Project

Vaitarna and Damanganga are two major rivers north of Bombay. The State Government of Maharashtra has proposed a major irrigation project which envisages construction of a dam across Pinjal river which is a tributary of Vaitarna river. The link project would provide additional water to the Metropolitan area of Mumbai to meet its domestic and industrial water requirement.

Considering that this water will be supplied for domestic and industrial use, the cost appears to be reasonable. The dams and links would all lie in the State of Maharashtra, though a small part of Damanganga catchment is in Gujarat state. Inter – state problems will thus be minimal.

West Flowing Rivers of Kerala/ Karnataka

Pamba - Achankovil - Vaippar Link

The Pamba-Achankovil – Vaippar Link Proposal envisages diversion of 634 Mm^3 from the surplus water available in Pamba and Achankovil river basin in Kerala State to the deficit Vaippar basin in Tamilnadu. Benefits from project include irrigation to 91,400 ha of area in Tamilnadu, generation of peaking power of 500 MW through pumped storage scheme and regulated releases of 150 Mm^3 during the lean period to Kerala. The scheme involves inter – state problems.

Netravati – Hemavati Link

NWDA has proposed Netravati – Hemavati Link to divert surplus water of west flowing river Netravati into East flowing river Hemavati (Cauvery basin) which is deficit sub – basin. The diverted water of Netravati basin will be stored behind Hemavati Dam and utilised to irrigate 33,813 ha under its command.

The project is entirely within the state of Karnataka. However, this is an import into the basin and may have to be taken into account in the total resource distribution of the basin. The cost is rather high due to requirement of lift. It would be worthwhile undertaking the project, if the water can be utilised for development of high value agriculture, horticulture and floriculture.

Bedti-Varda Link Project

Bedti river is one of the principal west flowing rivers of Karnataka State with a catchment area of 3,902 km^2. Tungbhadra river is a tributary of Krishna river. Total catchment of Tungbhadra river is 47,827 km^2 out of which 81.2 percent lies in Karnataka State. The link project proposes to transfer surplus waters of Bedti river to the Varda river to supplement supplies in Tungbhadra. The Bedti river basin and most of the Tungbhadra basin are in Karnataka state. However, this import may have to be taken into account in the total resource of the basin.

Southern Tributaries of Yamuna

Ken-Betwa Link Project

Ken-Betwa link envisages diversion of surplus waters of Ken Basin to water deficit Betwa basin. A 73.3m high dam is proposed on Ken river at Daudhan with gross storage capacity of 2,775 Mm^3. Total length of the link canal including 2 km long tunnel in its head reach is 231.45 km. One power house at the foot of the dam and other at the end of 2 km long tunnel are proposed with installed capacity of 60 MW and 12 MW respectively. The power house at the dam toe has provision for a pumped storage with downstream pondage behind Gangau weir.

Kalisindh – Chambal Link Project :

Kalishindh – Chambal link envisages transfer of water from Newaj river (a sub-tributary of Kalisindh river) and from Kalisindh river (a tributary of Chambal river) to Chambal river upstream of existing Gandhi Sagar/Ranapratap Sagar reservoirs. The water will be used for irrigation in the command of Chambal system taking off from Kota Barrage. The water thus saved will be utilised for irrigating the drought-prone areas in the upper reaches of Chambal river. It is not an inter-basin transfer of water as Kalisindh is a tributary of Chambal.

7.6 Draft Policy Guidelines

National Water Policy says that water should be made available to the water short areas by transfer from other areas including transfer from one river basin to another based on national perspective, after taking into account the requirements of the areas/basins.

Modified Draft National Policy Guidelines for Water Allocation amongst States have been under consideration since 1994. The guidelines include issues such as the national interest in maintaining the ecological health of rivers, the requirement of navigation in the National Waterways, and meeting international obligations.

The draft guidelines also say that a state would be free to utilise the allocated water in any part of its territory unless specific restrictions are warranted by overriding national priorities.

These are documents in draft stage and have to be taken up for finalisation in appropriate forums (Chapter – 8).

7.7 Economic Viability

The Commission is of the view that the criteria and methodology of economic analysis as applicable to other water resource projects should normally be applicable to Inter-Basin Transfer Projects taking into consideration the special features.

Inter basin transfer involves storage of water, construction of large canals and numerous major cross drainage works which may result in waterlogging and other environmental impacts more adverse than the normal water resources projects. These adverse impacts in the surplus state from which water resources are to be transferred to the deficit state are bound to cause opposition. There will be serious opposition from the environmental agencies and locally deprived people. This can be moderated if either the Centre or the recipient state compensates the state from which the water is transferred in some manner or if mutual quid pro quo is arrived at, not necessarily confined to the water sector.

The parameters B/C, B-C and IRR are used to evaluate WRD projects for justification and selection (ranking). Other social considerations like development of backward areas or drought prone areas are taken care of by prescribing a lower B/C ratio. Inter Basin Transfer project may involve other socio-economic objectives such as environmental quality, regional development, income distribution (i.e. equity) and employment generation. It may be difficult to evaluate all the environmental and social benefits in monetary terms.

Costs and benefits are computed by conventional methods. However, where prices are administered prices, free market prices are to be used. To further reflect social preferences, shadow prices of inputs in respect of under employed/scarce resources may have to be used. Similarly, product prices may have to be compared with international or import prices to determine opportunity costs.

Multi – objective evaluation is more appropriate for Inter Basin Transfer Projects. Normally, the plan formulation and economic evaluation are done in economic efficiency terms. In addition, costs and benefits are computed to assess general impact on other objectives. In other words, the level of contribution of the project on the specified components of the multiple objective are assessed and exhibited. More specific guidelines need to be provided.

Inter Basin Transfer schemes are quite large and complex in nature. Different components of the scheme have different functions, purposes to serve, as also different owners and stake holders. It is necessary to apportion the costs of each of such components for different purposes and /or partners. The principle of equitable distribution of cost should be prescribed.

7.8 Socio-Environmental Impacts

The problems associated with major water resources projects would also occur in Inter Basin Transfer projects, some in an intensified form. There would be some other peculiar problems. For example, fauna and flora not native to the recipient basin may be transferred to it through water links crossing the natural obstructions. Inter basin transfer necessarily requires storage at the supply end and preferably also at the receiving end which would involve large submergence. Similarly, construction of inter basin links would require construction of various major cross drainage works and obstruct/intercept natural drainage leading to water-logging conditions. On the other hand, inter basin transfer of water would overcome temporal and spatial imbalance in availability of water. Inter basin transfer will (i) create social cohesion and national integration, (ii) balanced development of all regions due to increased agricultural activity in water scarce regions and (iii) reduce drought prone areas.

7.9 Funding of Inter Basin Transfer Projects

Funding interbasin projects will have to be looked into from several considerations :

- Should the project be considered as a whole constituting a large grid or can each link be separately considered in respect of availability, execution and utilisation ?
- Should such a project be taken up as a Central Project or as Joint Project involving the Centre and the concerned States or as a Joint Project of the States concerned ?
- Can all the benefits accruing from such individual links be identified in detail and apportioned to the beneficiary States/ Centre ?
- Can all the benefits accruing from such individual links be identified use – wise and allocated among the drinking water/ irrigation/ power generation/ recreation and so on ?

The answers, which will have to be arrived at through negotiations, will be project specific. The agency decided upon to execute the project will also have to look to the source for funding. The possible sources are :

- From the regular budgetary allotments of the State/Centre.
- Raising loans for the special projects through bonds/debentures etc., by the respective Government of the State/Centre.
- Posing the projects to the external agencies like the World Bank, European Economic Community, the Japanese Aid, ODA and so on and negotiating with them on interest rates, phasing of funding, reimbursement etc.
- Inviting private Companies for Build, Operate and Transfer (BOT) mode or some other arrangement.
- Levy of Betterment Tax and the like on the beneficiaries and raising atleast part funding.

Considering the large investments involved, recovery of cost over a period of time needs to be aimed at, though it will not be an easy proposition. Part of the recovery should be from the general population of the recipient area who would benefit from stimulation of economic development and part from the particular individuals, industries or communities receiving such water.

7.10 General Observations

Inter-basin transfer of water is a very important and outstandingly large complex programme of water management. The study has to be put on modern lines of scientific engineering work with necessary institutional changes and transparent participatory work. This can best be done with the help of computer simulation models and systems analysis. Hence, an established agency working on inter-basin transfer should concentrate on detailed sub-basinwise, conventional and computer modelling studies taking both surface and ground water resources into account. In fact, computer simulation models are urgently required even for intelligent and coordinated operation of a number of storages already built or under construction in these basins.

Sustainable development requires rapid economic development with equal emphasis on environmental protection. Studies should be taken up to scientifically estimate the availability of surface and ground water. River Water Tribunals have not included ground water in their evaluations of water availability. There are some uncertainties about the assessment of ground water and its interaction with surface water which need to be studied in detail. Estimation of sector wise water demands, their management and implications of quantity and quality are extremely important. Minimum river flows have to be maintained from environmental considerations which need to be studied. Innovations in economical use of water and increased productivity should be taken up. Demand analysis, hydrological cycle dynamics and system studies should be undertaken together to determine the sustainable development policy. Technological developments have to be kept under review and adopted or improved, wherever possible. Above all, we would have to re – emphasize that the basic problems are not techno – economic, but those of a political, social and emotional character. The country's political system and civil society have to evolve institutions and techniques to deal with them and arrive at solutions in the best interest of the people.

CHAPTER – 8

LEGAL AND INSTITUTIONAL FRAMEWORK

In this chapter, we consider the legal and institutional issues that arise for consideration in the context of the future direction of effort that we have suggested in the report regarding development and management of our water resources.

I. Legal Issues

The development and management of water resources during the last 50 years has thrown up many important legal issues, starting from the provisions in the constitution to the inadequacies in Central and State laws and the need for new laws. Laws, by themselves, do not solve problems, but an appropriate legal framework is a necessary condition to establish institutions and arrangements for development and management and for resolution of disputes. Water Law is an important specialisation and there is wealth of literature on it regarding relative rights and responsibilities of communities, sub-national units and countries. It is not possible for us to attempt an analysis of all the issues that arise under water law nor is it necessary for our purpose. We consider in this chapter only the more important issues that have arisen in our country and which affect speedy and integrated development, management and conservation of water resources.

8.1 Constitutional Provisions and Existing Laws

The Constitution of India lays down the legislative and functional jurisdiction of the Union, State and local Governments regarding 'Water'. Under the scheme of the Constitution, 'Water' is basically a State subject and the Union comes in only in the case of inter- state river waters.

List II of the Seventh Schedule, dealing with subjects regarding which states have jurisdiction, has the following as Entry 17 :

"Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of Entry 56 of List I

Entry 56 of List I (Union list), reads as follows:

"Regulation and development of inter- state rivers and river valleys to the extent to which such regulation and development under the control of the Union, is declared by Parliament by law to be expedient in the public interest".

The Constitution has a specific article (Article 262), dealing with adjudication of disputes relating to matters of inter- state rivers or river valleys, which reads as follows:

Article 262 (1): Parliament may by law provide for the adjudication on any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter- state river or river valley.

(2) Notwithstanding anything in this Constitution, Parliament may by law provide that neither the Supreme Court nor any other Court shall exercise jurisdiction in respect of any such dispute or complaint as is referred to in clause (1).

The recent 1992 amendments to the Constitution regarding Panchayats and Municipalities introduced the following entries in the schedules listing the subject-areas in which the State Governments and legislatures may devolve functions to such bodies, so as to make them evolve as local self-governing institutions:

> In the Eighth Schedule (Part IX) dealing with Panchayats, the subjects, "Minor irrigation, Water management and Watershed development", "drinking water" and "maintenance of community assets" are listed.
>
> In the Twelfth Schedule (Part IX A) dealing with municipalities, the subjects "water supply of domestic, industrial and commercial purposes" is listed.

Functional responsibilities are, thus, visualised for local Governments in respect of several aspects of water use.

The two laws enacted by the Union under Article 262 and Entry 56 of List I are the Inter-State Water Disputes Act, 1956 (as amended up to 1980) and the River Boards Act, 1956. In recent years, since the Constitution does not have an entry relating to 'Environment', using the residual powers, the Union has enacted laws on environment and control of pollution, which have effect on water use, including ground water and its exploitation.

A large number of Acts dealing with irrigation, canals and their maintenance, water rates and cess, command area development and maintenance of tanks are in force in each state. Some of the Acts are as old as the 1860s and 70s. An illustrative list of Acts in force in one of the states (Tamil Nadu) is given in Annexure 8.1.

The major issues that have been raised for consideration in the context of developments in the sector are :

1) Should (and could) 'Water' be made a Union/Concurrent subject in the Constitution, so that water can be treated as a national asset and legislation enacted with a national perspective?

2) Apart from a few sporadic efforts, the basins of major rivers are not considered in our country as hydrological entities for development and for sustainable and equitable use of waters. What changes in the existing laws or new laws would help?

3) Inter- state river disputes take a long time to be resolved. What changes could be made in the existing laws to speed up the process and to ensure faithful implementation?

4) There are suggestions, from time to time, for inter-basin transfer of waters. What are the legal issues and should any new law be considered?

5) Major issues of water rights have arisen especially in the context of exploitation of ground water. How should we deal with them?

6) Almost all the State Irrigation Acts retain control and delivery in departmental hands. How to make the laws farmer-friendly, so that the farmers are fully involved and the departments provide supporting services to them?

7) The existing structure of institutions dealing with water at the national, state and local levels need to be revamped. Would legal backing be an advantage?

8) Basic questions regarding rights of water use, water and land conservation, conjunctive use of water from different sources, environmental considerations, displacement of persons in the case of large projects, people's involvement in water development and management, principles of pricing of water and rights and responsibilities of governments, users, communities and individuals, arise during development. Would a National Water Code be useful in the context?

These issues are briefly discussed below, not necessarily in the same order:

The view has been expressed by many observers in the field of 'Water' that it is only by taking legislative powers on all 'Water' – not merely inter- state rivers - that a national perspective can be applied and laws for integrated and economic uses of water could be enacted. Integrated water development does not mean only large projects on major rivers, but integrated use and conservation of all sources of water, as an increasingly scarce natural resource. The entry of 'forests' as a concurrent subject, greatly helped to arrest the deteriorating trend in forest wealth, because of stringent legislation by the Union. In the case of 'Water', it has not been possible to get the states to enact suitable irrigation laws and in the case of ground water, despite the fact that the situation has reached alarming proportions in certain areas, the states are not passing the necessary laws. There is also need for collecting nation-wide, reliable data on water.

The Sarkaria Commission on Centre- State Relations, examined this question in detail. They pointed out that the scheme of the Constitution was that there was need for Union control over waters of inter- state rivers and river valleys for their regulation and control, but in matters of local concern, as in the case of 'land', states should have powers in respect of waters, which are not part of inter- state rivers and are located within the territory of each state. This is because inter- state waters are not located in the state and only flow through their territories. No state, can, therefore, lay claim to the exclusive use of such river waters and/or deprive other states of their just share. Since the jurisdiction of a state, by virtue of Article 245 is territorially limited, only Parliament could have powers to regulate, by law, the beneficial use and distribution of such waters among the states. The Sarkaria Commission, therefore, was of the view that the existing arrangements in the Constitution are the best possible method of distributing powers between the Union and the States with respect to a highly sensitive and difficult subject. They were unable to support the suggestion that 'Water' should be included in the Union list. Presumably, for the same reasons, the Commission ruled out entry of the subject in 'concurrent list' also.

Doubts could be felt whether the Sarkaria Commission was entirely right in giving a ringing endorsement to the existing provisions. First, even the most general entry regarding water, namely, Entry 17 in the State List, quickly slips into specific uses of water such as water supply and irrigation. Second, irrigation looms large, and the reference to canals, embankments, drainage, water storage, etc., shows the heavy influence of the engineering point of view. Third, while the word 'Water' may be taken to include groundwater, there is no specific reference to the latter; the Constitution-makers seem to have been thinking mainly of river waters. Fourth, a simple distinction has been made between intra- state rivers and inter- state rivers and a role given to the Centre only in respect of the latter, this indicates a failure to recognise that state action or inaction even in relation to a wholly intra- state river can have consequences beyond the borders of the state. Fifth, there is no clear recognition that water is a national resource and that acutely water-short areas of the country have a right to a share in the water endowment of better-placed states. Lastly, the constitutional provisions do not show any direct perception of water as a natural resource, much less as a part of the larger environment or the ecological system. Some of these perceptions and concerns are of relatively recent origin, and were not before the Constitution makers.

It seems plausible to suppose that if all these considerations had been before the Constituent Assembly, the constitutional provisions would have been different. These reflections have their validity, but what we have are the existing provisions, and the whole question ultimately boils down to what is politically feasible. It is a fact that the centre could not enact effective laws regarding inter- state rivers, even when it has the powers, and that even the laws, such as they are, have not been implemented fully. The centre could enact overriding laws regarding industry and business using relevant constitutional powers, even though they are state subjects, but water is such a politically sensitive issue that the centre refrained from being pro-active even during the decades of increasing central role in many other sectors. The current political trends are towards greater decentralisation and debureaucratisation. It does not seem realistic to expect that 'Water' can be got included in the concurrent list. There have been proposals, from time to time, to include certain subjects in the concurrent list, but none could be included so far. It is well to remember that 'Forests' got included in the concurrent list during the 1975-77 emergency.

We are not, therefore, proposing any change in the scheme of the Constitution. What is needed now is for the Union to pass laws to more effectively deal with inter- state rivers. There is also need for the Union to put in place Centre- State consultative machanisms of an effective kind, through which the centre and the states could agree on a number of issues relating to water.

8.2 River Basins As Units of Development

The need to treat each river basin as a hydrological unit for national development of all its sub-basins is well-recognised, but the efforts in this direction, after the initial Damodar Valley Project, have not been adequate or effective.

Parliament enacted the River Boards Act, 1956, under Entry 56 of List I, to promote integrated and optimum development of the waters of inter- state rivers and rivers valleys. That Act contemplated the appointment of River Boards by the Central Government in consultation with the State Governments for advising on integrated development of waters of inter- state rivers and river valleys. It was envisaged that the Boards would help in coordinated and optimum utilisation of the river waters and promote development of irrigation, drainage, water supply, flood control and hydroelectric power. However, the provisions of the Act have not been put to use in all these years and the Act has remained a dead letter. There is not a single river basin authority in India under the River Boards Act.

As can be seen from the wording of the Act, it provides only for advisory Boards and not for River Basin Organisations vested with powers of management. In fact, no river boards, even of an advisory kind, have been set up under this Act. The Betwa River Board was set up by a separate enactment, for overseeing the project. The Brahmaputra Board set up under a specific Parliamentary enactment was vested with powers of execution of projects, but its role was confined largely to the preparation of a Master Plan. Various organisations were set up under Government Resolutions: Bansagar Control Board for supervising specific projects, the Narmada Control Authority set up under the orders of Narmada Waters Disputes Tribunal with limited functions relating to cost allocations and the rehabilitation of project affected persons and monitoring of environmental aspects. Certain other Boards were formed by mutual agreement. All these Boards have limited functions and powers. We are of the view that the River Boards Act in its present form will not help in planning the available water resources of a basin in an optimal fashion. No follow-up action has been taken on the National Water Policy, adopted in the year 1987, which suggested that appropriate organisations should be established for the planned development and management of a river basin as a whole.

While dealing with institutional questions later in this chapter, we urge the need for forming an Organisation for each inter- state river. We also give the outline of a model which could be adopted in our country. We would strongly urge the enactment of a law on inter- state rivers, in the place of the River Boards Act, called the Inter- state Rivers & River Valley (Integrated and Participatory Management) Act. The Law could provide, in addition to the constitution of the proposed river basin bodies, for all other matters like collection of data, major principles of allocation among the concerned states, principles of basin development including local watershed development, issue of guidelines for major projects by the Union, prescription of technical standards by the CWC, need for approval by appropriate authority (See below) before taking up projects on inter- state rivers and such other related issues. The passage of such a law may be resisted by a few states, but it is essential and we believe that a consensus could be worked out through serious consultations and discussions as suggested by us in the section on institutional questions.

8.3 Inter- state Water Disputes

The regulation and development of waters of many Inter- state rivers and river valleys in our country, continue to be a source of friction. Parliament enacted the Inter- State River Water Disputes Act in 1956 under Article 262 of the Constitution and barred the jurisdiction of courts in regard to such disputes. As per the Act, if any request is received from any State Government in respect of any water dispute and the Central Government is of opinion that the matter cannot be settled by negotiations, the Central Government shall by notification in the official Gazette, constitute a Water Dispute Tribunal for the adjudication of the water dispute.

Since the enactment of the law, five Inter- State Water Disputes Tribunals were set up for adjudicating water disputes in respect of Krishna, Godavari, Narmada, Cauvery and Ravi – Beas rivers. The awards of Krishna, Godavari and Narmada resulted in resolution of the dispute regarding allocation of waters. However, this did not work in case of Ravi-Beas dispute ; the final settlement in that case is getting delayed for one reason or other.

In the case of Cauvery Dispute, the adjudication has been running a troubled course. First, (since the Karnataka Government had serious reservations on adjudication in this case) there was a delay in the establishment of the Tribunal. The Central Government set up the Tribunal four years after the request in 1986 by the Tamil Nadu Government and only on a direction of the Supreme Court. An Interim Order given by the Tribunal in 1991 itself generated a secondary dispute. On the ground that it was a not being fully implemented, the Tamil Nadu Government sought a direction from the Supreme Court that it should be implemented. The Supreme Court referred the matter to a Constitution Bench. However, before the Constitution Bench could give a ruling on the matter, the Central Government in response to pointed queries by the Supreme Court as to the role it proposed to play in regard to the implementation of the Interim Order came up with a Scheme for the purpose. The 'Cauvery Waters (Implementation of the Order of 1991, and all Subsequent Related Orders of the Tribunal) Scheme 1998' was notified by the Government of India on 11th August, 1998. Following this, the Tamil Nadu Government, on an enquiry by the Supreme Court, withdrew the petition that was pending before the Constitution.

Three points deserve to be noted in this context. The first is that the initial intention of the Central Government to establish a professional Cauvery River Authority could not be carried through, and instead, a political body was set up. To the extent that this was acceptable to both the State Governments it is to be welcomed, but this solution is fraught with some difficulties. Secondly, an opportunity for the Supreme Court to pronounce on the status of a Tribunal's order, that is whether its implementation is mandatory or not, has been missed. This question will come up again in the future. Thirdly, while the secondary dispute concerning the implementation of the Interim Order can be said to have been resolved in a manner, the water dispute itself has not yet been settled. The proceedings before the Tribunal are continuing, and in due course we shall have to see whether its Final Award marks the end of the dispute, or is in turn followed by further difficulties.

In the case of Narmada, submergence of areas, displacement of large numbers of tribal people and their rehabilitation became major issues after the implementation of the project was started and public interest cases are still pending in the Supreme Court and the project work had to remain suspended for some years.

The point to be noted is that the Government of India has been unable to act as required and that while the courts are barred from reviewing the awards of the tribunals, matters still go before the Supreme Court on related legal, jurisdictional and constitutional issues. Such questions may not normally be raised on over-all allocations, but questions relating to environmental aspects, displacement and rehabilitation of people and human rights are increasingly being raised before the Courts in the case of specific projects.

Thus, experience of the past shows that a long time is taken in constituting a Tribunal and in giving the award, leading on occasions, to the pronouncement of interim awards, which lead to several complications. Also, after the grant of the award, problems of interpretation and implementation arise, and there is no mechanism to enforce the binding character of the award. The matter is also taken to Court, not on the allocation of water, but on other issues in the context of specific projects, further delaying for years the implementation of projects.

The Sarkaria Commission, which examined the issues in great depth, recommended the following :

1. Once an application under Section 3 of the Inter- State River Water disputes Act (33 of 1956) is received from a state, it should be mandatory on the Union Government to constitute a Tribunal within a period not exceeding one year from the date of receipt of the application of any disputant state. The Inter-State River Water Disputes Act may be suitably amended for this purpose.

2. The Inter-State Water Disputes Act should be amended to empower the Union Government to appoint a Tribunal, *suo-mottu,* if necessary, when it is satisfied that such a dispute exists in fact.

3. There should be a Data Bank and Information System at the national level and adequate machinery should be set up for this purpose at the earliest. There should also be a provision in the Inter-State Water Disputes Act, that states shall be required to give necessary data for which purpose, the Tribunal may be vested with the powers of a Court.

4. The Inter- State Water Disputes Act should be amended to ensure that the award of a Tribunal becomes effective within five years from the date of constitution of a Tribunal. If, however, for some reasons, a Tribunal feels that the five years' period has to be extended, the Union Government may on a reference made by the Tribunal extend its term.

5. The Inter- State Water Disputes Act, 1956 should be amended so that a Tribunal's award has the same force and sanction behind it as an order or decree of the Supreme Court to make a Tribunal's award really binding.

The Inter-State Council and its Standing Committee considered these recommendations in detail in consultation with the states and the Ministry of Water Resources and finally, the Council took the following decisions at its fourth meeting held on 28th November, 1997:

The Council endorsed Recommendations 1,3 and 5 above in toto and did not agree to Recommendation 2. As regards, Recommendation 4 above, the Council decided as follows :

> "The Tribunal should give its award within a period of three years from the date of its constitution. However, if for unavoidable reasons the award could not be given within a period of three years, the Union Government may extend the period suitably not exceeding two years. The award should be implemented within two years from the date of notification of the award. If for unavoidable reasons the award could not be implemented within a period of two years, the Union Government may extend the period suitably".

The Council also decided that disputes once settled should not be allowed to be raised or reopened and that guidelines should be evolved on the broad principles of sharing of river waters. The necessary amendment bill to give effect to these decisions has not yet been introduced in Parliament.

Several other suggestions have been made, including the one that Article 262 and the ISWD Act may be repealed. The suggestion is that the dispute may be sought to be settled by mutual agreement and if it is not found possible, the matter may straight away be taken to the Supreme Court. Another suggestion is that an appeal to Supreme Court may be provided for, on the awards of the tribunals, since matters are taken to court in any case and it is only a judgement of the Supreme Court that is taken as final. It appears to us that these are counsels of despair due to the existing long delays. Article 262 was introduced because the framers of the Constitution recognised that water disputes could not be adjudicated only on legal considerations and that other considerations have to be taken into account. Direct adjudication of disputes by the Court is not likely to reduce delays at all. As regards the suggestion to provide for an appeal to the Supreme Court, it would only further delay matters badly. As stated above, it is not matters adjudicated by the Tribunal that are taken to the Court, but issues arising out of non-implementation of the award or questions arising in the context of specific projects.

We are of the view that Sarkaria Commission has made very useful suggestions. It is a matter for gratification that through the instrumentality of the Inter-State Council, a measure of agreement has been reached among all concerned. We believe that efforts at mutual agreement should first be made at the river basin level, through the mechanism of the River Basin Organisation (RBO), suggested by us. The methods of conciliation and arbitration can also be tried by the RBOs. However, if the disputes cannot be resolved, within a reasonable time by these means, it may be referred for adjudication by a Tribunal. We recommend that immediate steps be taken to amend the ISWD Act on the lin~~es~~ agreed upon in the Inter-State Council, with the following additions :

- Provision may be made for efforts at settlement at the river basin level, as and when RBOs are formed.
- When any matter is referred back to the Tribunal for clarification under Section 5(3) of the ISWD Act, the Tribunal should give its final verdict within a period of six months and the Central Government shall notify and publish the award/decision of the Tribunal within three months.

- The Tribunals should hear the views not merely of the contestant states, but all other stakeholders, who may implead themselves in response to a public notice and who, in the judgement of the Tribunal, have a stake in the dispute.

8.4 Inter Basin Transfer of Waters

The Constitutional and existing legal provisions do not specifically permit or prohibit the transfer of surplus flows from one basin to a deficit basin. The issue had come up before some of the inter-state water Tribunals. The question came up before the Krishna Water Disputes Tribunal and Narmada Water Disputes Tribunal. The issue before the Krishna Water Disputes Tribunal was:

" Should diversion or further diversion of the waters outside the Krishna drainage basin be protected and/or permitted? If so, to what extent and with what safeguards?"

The state of Karnataka (then Mysore) expressed that the diversion outside the basin is illegal and only intra-basin needs should be considered in deciding the equitable share. Andhra Pradesh felt that outside basin needs are a relevant factor but only irrigation needs should be permitted. After reviewing the international experience, the Tribunal decided that (I) the diversion of water outside the river basin by a state are legally valid, (ii) needs for diversion outside the basin are relevant to equitable allocation and (iii) however, more weightage should be given to the intra-basin use.

In its order the Krishna Water Disputes Tribunal put considerable restrictions on inter-basin diversions of the water towards the Arabian Sea for hydroelectric purpose. However, except for such specific restrictions, it allowed the water allocated to any state to be diverted by the state outside the basin.

The Tribunal, in its order, allocated the dependable flows amongst the states. However, it gave to Andhra Pradesh, the most downstream riparian state, the liberty to use in any water year, the remaining water without acquiring any rights whatsoever. Karnataka had sought clarifications to indicate that the liberty given to Andhra Pradesh does not confer any right of diverting these remaining waters outside the basin. The Tribunal did not agree to give any such clarification.

The Tribunal also considered the question of inter-basin transfers by the basin states from outside the Krishna basin to within the Krishna basin. Such possibilities of transfer from the Godavari were attracting much attention at that time. Both Maharashtra and Karnataka sought for a direction that waters of Godavari be diverted to Krishna, while Andhra Pradesh opposed this. Afterwards an agreement was reached amongst the basin states that each state would be at liberty to divert the Godavari waters, which may be allocated to it by the Godavari Tribunal, to any other basin.

Maharashtra and Karnataka wanted the Krishna Tribunal to pass self executing order providing for equitable distribution for such diversion of water (from Godavari to Krishna). Alternatively, they wanted that in case of waters of Godavari, the Ganga or any other rivers are diverted to Krishna, they should have the liberty to claim the benefits of the diverted water. Andhra Pradesh disputed this. (Here the mention of diversion from Ganga etc. in particular refers to inter-basin diversion to non basin states since none of the Krishna basin states are in the Ganga basin).

The Tribunal indicated that the review after year 2000 would look into such issues. However, the final order of the Tribunal provided that in the event of augmentation of Krishna water by any source, no state shall be debarred from claiming before any authority or Tribunal, even before year

2000, that it is entitled to a share in the water of the Krishna on account of the augmentation, nor shall any state be debarred from disputing such claim. Thus, in short, the Tribunal has recognized that diversion of waters from any other basin at any point by any basin state or others could give rise to another (subsidiary) dispute which would have to be settled amongst basin states in some manner.

This issue thereafter got considered by the Godavari Water Disputes Tribunal (which had the same membership as the Krishna Tribunal) as also by the Godavari basin states. Through a series of inter- state negotiations and agreements it was agreed that subject to the clearance of CWC the Polavaram Project would provide for diversion of 80 TMC of the dependable water of Godavari to Krishna above Vijayawada and that by a principle of displacement, this water would be utilized by Andhra Pradesh, Karnataka, Maharashtra in the agreed quantum of 45, 21 and 14 TMC respectively. This agreement was suitably incorporated in the final orders of the Tribunal so that the subsidiary dispute due to transfer of water into Krishna basin mentioned earlier got settled through another process of negotiations and adjudications. However, there are some other proposals of possible diversions of the water of the west flowing rivers of Karnataka into the Krishna basin. The possibility of subsidiary disputes seem to be a reason in not allowing finalisation of such schemes.

The Narmada Water Disputes Tribunal has not dealt exclusively with the issue of the legality of the water by the basin states in their territories outside the basin areas. The issue considered by the Tribunal was the claim of Rajasthan, a non riparian state for a share of water of inter- state river Narmada. Gujarat relied heavily on use of Narmada waters in the northern regions of the state also. The case of Madhya Pradesh and Maharashtra was that Rajasthan has no right to share Narmada waters as it was a non-riparian state. This was upheld by the Tribunal in a preliminary decision. Rajasthan appealed to the Supreme Court, but later withdrew the appeal. However, subsequently the party states signed an agreement allowing the share of 0.5 MAF of Narmada waters for Rajasthan. The Tribunal opined that the right to Rajasthan is based on this agreement and not on the general law. On this basis, Rajasthan was made a party to the dispute and its agreed claim was incorporated in the orders of the Tribunal. While doing so, the Tribunal made the following observations:

" It may perhaps, be open to Parliament to enact a law in exercise of its authority under Entry 56 of list I of the Seventh Schedule not only apportioning the waters of the Narmada river between the riparian states of Gujarat, Madhya Pradesh and Maharashtra, but also give a share to Rajasthan. The Constitution may also perhaps be amended so as to expand the scope of Entry 56 of List I so as to include apportionment, control and use of waters of all inter- state rivers which are declared by Parliament by law to be expedient in public interest. If the Constitution is so amended and the appropriate law is enacted by Parliament, the rights and interests of the riparian states of Narmada under Entry 17 of List II would be superceded and Law enacted by Parliament would prevail".

Regarding international experience, no information is available about inter-basin water transfers where the water is transferred to a non-basin country. It is known that such plans, particularly in regard to the Nile were made but perhaps there has not been any progress in reaching an agreement. It would be difficult to imagine that basin nations of an international river would concede any right on its water to non-basin nations. At best, such use may perhaps result from an intranational inter-basin transfer scheme later becoming an international scheme due to a process of fragmentation.

The international Conventions provide only for the equitable sharing of the water by the basin states and clearly do not provide for any sharing by non basin states. However, in some cases, the concept of " Common terminus" can perhaps be applied in a broader sense to make the basin larger and thus to make otherwise non-basin states as basin states. Also, the definition " Water course state" in the Convention includes regional economic integration organisation. It is not known whether such an organisation can get water allocated to it and in turn share it in part with an otherwise non basin state. This perhaps may not be the intention since a separate statement of understanding in regard to these conventions explains that the inclusion of the regional economic integration organisation in the definition does not imply that these have the status of states in international law.

There are many large nations with a federal type of structure, such as the USA, Canada, Australia, etc. The legal aspects of inter-basin transfers in such countries need to be studied further, since, to some extent their experience would be useful in the Indian context.

In our own country, there have been instances of diversion from one basin to the other, by mutual agreement, though the quantum of diversion is small. The notable examples are the diversion through K.C. Canal, Telugu Ganga, Periyar-Vaigai and Parambikulam-Aliyar Project. There have also been exercises at national level to study the possibility of inter-basin transfers. We have considered these questions in detail in the previous chapter. Here we would only like to note that no state is willing to accept that it has surplus flows, over and above its requirements. States are unwilling to accept computed surpluses. They question the methods of calculation of surplus and raise the point that inter-basin transfer within a state, should be considered first. They also question the criteria for defining "national requirement". However, State Governments are prepared to share their waters on mutually acceptable terms without going into the issue whether a particular basin has surplus or deficit.

There is need for institutional arrangements with the requisite legal backing for making the states to come together for holding serious discussions on sharing of waters including diversion to non-basin states, ultimately paving way for reaching an agreement on the basis of mutual needs. Several innovative ways are possible. We feel that one such arrangement could be through the mutual discussion and arriving at an agreement by the River Basin Organisations of the respective basins.

As for legal provisions, the Inter-State Rivers (Integrated and Participatory Management) Act proposed by us, may provide for studies to be made by the Union for possible inter- state inter-basin transfers, so that the work of NWDA has statutory backing and the organisation would be able to obtain information and cooperation for its studies. The studies and alternatives proposed in them and the feasibility reports would hopefully assist in arriving at mutual agreements.

8.5 Water Rights

Traditionally, the basic elements : space, air, water and energy have been perceived as non-legal objects that are incapable of becoming property. The Roman Law did not ever classify running water as capable of becoming someone's property. No ancient Indian text mentions property rights to anyone, including the king, in rivers.

The system of riparian rights generated by common law gives 'rights in a stream ratably to all persons owning land along the stream'. The riparian system regards all owners of land bordering upon the stream to be on an equal footing. A riparian owner has a right to have the water come to him undiminished in flow, quantity or quality and he has a duty to let the water go beyond his land without diminishing its quality and quantity.

The acute need of water for raising crops in our country and the general British approach towards natural resources made the government create a legislative frame work for irrigation. Different legislations were adopted in different parts of India. The Preamble of the Northern India Canal and Drainage Act, 1873, which extends to U.P., Punjab, Delhi says: ... 'The provincial Govt. is entitled to use and control for public purposes the water of all rivers and streams flowing in natural channels and of all lakes and other natural collections of still waters'. The Bombay Irrigation Act, 1879 has also similar provisions, that is, "where it appears expedient to the [(State) Govt.] that the water of any river or stream flowing in a natural channel or of any lake or any other natural collection of still water, should be applied or used by the [(State) Govt.] for the purpose of any existing or project canal [(the State) Govt.] may, by notification in the (Official Gazette), declare that the said water will be so applied or used after a day to be named in the said notification, not being earlier than three months from the date thereof". The Acts do not discuss the ownership of 'water'. The Irrigation Laws recognise the riparian system of rights asserting the rights of the state to use and control water in all public rivers and natural collection of still water subject to the liability to compensate for displacement of existing riparian rights or rights acquired by prescription.

The coming of the Easements Act in 1882 made the first radical shift in the history of Indian Law, in both recognising and not recognising water right as a negative natural right. The illustration (j) to Section 7 of the Act refers to the right to every owner of land abutting on a natural stream, lake or pond to use and consume its water for drinking, household purposes and watering his cattle and sheep and the right of every such owner to use and consume the water for irrigating such land, and for the purposes of any manufactory situated thereon, provided that he does not thereby cause material injury to others like owners. However, this right is always subject to the overriding power of regulating water source as contemplated under Section 2 of the Act, which reads :

'Nothing herein contained shall be deemed to affect any law not hereby expressly repealed; or to derogate from – "(a) Any right of the Government to regulate the collection, retention and distribution of water of rivers and streams flowing in natural channels, and of natural lakes and ponds, or of the water flowing, collected, retained or distributed in or by any channel or other work constructed at the public expense for irrigation'.

The rights claimed in respect of surface water and the property based ground water rights are unsuited to conditions in which water resources are scarce and fierce competition and not easy co-operation for water, mark the scene. Even in the United States of America, where resources are abundant, changing socio-economic conditions led to restrictions on riparian rights limiting access to water only for reasonable use.

Among the various suggestions offered in this context, one is for centralisation in the hands of the state of all control on water resources. Some of the erstwhile socialist economies had legal systems vesting centralised control of water resources in the hands of the state. This model may not be acceptable in our country. The example of the Ground Water Bill which could not be enacted into law even after a score of years needs serious consideration. The fact that a subject is (or should be) under public domain does not mean that it should be controlled only by the state. The legislation can provide for collective self-regulation. It is suggested that equitable and reasonable utilisation of water can be brought about without state control and by accepting it in practice. For example, local communities (at village or watershed level) could be empowered to regulate the use of water in watershed areas. The issues involved in ground water regulation are discussed in greater detail in the following section.

A typical situation may arise when the villagers through their own shared efforts bring life into a dead river, as it happened in the case of a village in Rajasthan recently (study of the rivulet Arvari, Alwar District, TBS) and then claim rights to reap the benefits of the river water. The villagers are bound to be at logger heads with the State Authorities, who, by the virtue of Indian Easements Act, 1882 have the sole right to regulate the collection, retention and distribution of the waters of rivers and streams flowing in natural channels and of natural lakes and ponds, or the water, flowing, collected, retained or distributed in or by any channel or other work constructed at the public expense for irrigation. We are of the opinion that so far as the major and medium rivers and streams are concerned the state may continue to have the right of regulation, collection, retention and distribution of water, however, small rivers and minor streams could be managed by the village communities and the laws should enable this.

8.6 Ground Water Regulation

Ground Water is considered an easement connected to land tenure laws and the dominant heritage principle implicit in the Transfer Property Act IV 1882. The illustration (g) to Section 7 of the Indian Easements Act 1882 refers to the right of every owner of land to collect and dispose within his own limits of all water under the land which does not pass in a defined channel. All ground water existing and found beneath private property is fully under the control of owner of the land, who is free to extract and use it as he or she seems fit. This has led to a 'defacto' right at the field level, where affluent farmers with higher pumping capacity and deeper tubewells have disproportionate claims over the resources than others. Inadequate regulatory restrictions on the exercise of private property rights in ground water resulted in excessive withdrawals in many areas. Further, uncontrolled disposal of industrial wastes, sewage affluents and excessive use of chemical fertilizers have affected the quality of ground water and the problem is acute in some states like Gujarat. In order to control and regulate the ground water from quantity and quality angles, the Government of India formulated a model bill and circulated to various State Governments for adoption.

The Ministry of Agriculture had circulated to the states a draft model bill for control and regulation of ground water, in the year 1970. The bill was revised twice, once in 1992 and then in 1996 by Ministry of Water Resources.

The Salient features of the Model bill (1970) are :

- The State Governments were to acquire powers to restrict the construction of ground water abstraction structures (including wells, borewells, tubewells etc.) by individuals or communities for all uses except that of drinking water in any area declared as notified area based on report from Ground Water Authority of State in Public interest.

- For discharging the various functions to be acquired by the Government under the legislation, a Ground Water Authority was to be constituted by each state. The Authority was to consist of a Chairman, representatives of the concerned State Government Departments and knowledgeable persons in the field of ground water appointed by the State Government. The Authority was to be provided with support of technical persons and other staff considered necessary for enforcing the legislation.

- Applications for sinking wells for purposes other than domestic use were to be considered by the Ground Water Authority keeping in view the purpose for which water was to be used, the existence of other competitive users, the availability of ground water and any other relevant factors.

- Persons/Organisation desirous of taking up the business of sinking of wells/tubewells were required to register with the Ground Water Authority. The Authority was also to be vested with the power to cancel any permits, registrations or licenses issued by them.

- Finally, the Authority was to be provided with complete legal support to enforce the various provisions of the legislation. It was also provided that the orders issued by the Authority would fall outside the purview of the Civil Court. The Civil Courts were to be barred from granting injunctions on any decision taken by the Authority.

The following provisions were included in the revised version of Model bill (1992):

- Extension of the bill to cover all uses including drinking and domestic use, and exemption of small and marginal farmers from obtaining prior permission of the Ground Water Authority for the construction of ground water abstraction structures, provided these are for their exclusive use.

- Small and marginal farmers are not required to obtain permit to extract and use ground water in the notified areas, provided well was to be sunk for personal use (not commercial).

The latter provision was substituted by the following provision in the 1996 version of the model bill:

'The person or persons will not have to obtain permit if the well is proposed to be fitted with a hand operated manual pump or water is proposed to be withdrawn by manual devices'. Further, the latest bill warrants that all wells sunk in the non-notified areas with certain exceptions require registration.

Only a few states have enacted Ground Water legislation (that too in restricted areas and for limited purposes). Others have started contemplating legislation of some kind. The Model bill was also released to the press to ascertain public reaction. Whereas the need for a law was generally accepted concern was expressed that the legislation involving licensing and approvals will lead to widespread corruption and harassment of the general public and the bill was viewed as a policing measure. Alternative suggestions have been made for regulation and management by the local community. Ministry of Water Resources itself has since been suggesting to State Governments that a participatory approach needs to be adopted, wherein people themselves would regulate the drawal of ground water, assisted by a hydrogeologist from the Ground Water Board.

As per the orders of the Supreme Court, the Ministry of Environment & Forests have constituted the Central Ground Water Board as an Authority. The Central Ground Water Authority (CGWA) shall exercise the powers and perform functions as follows :

- Exercise of power under section 5 of the Environment (Protection) Act, 1986 for issuing directions and taking such measures in respect of all the matters referred to in subsection (2) of Section 3 of the said Act.

- To resort to the penal provisions contained in sections 15 to 21 of the said Act.

- To regulate indiscriminate boring and withdrawal of ground water in the country and to issue necessary regulatory directions with a view to preserve and protect the ground water. The Authority will function under the administrative control of Ministry of Water Resources with its headquarters at Delhi and will have jurisdiction over entire India.

A Workshop on the Methodology and Functioning of CGWA held in May, 1997 recommended that while the CGWA will be mainly responsible for framing guidelines, policy statements and monitoring the implementation of the purpose for which the Authority has been constituted, the State Government may consider enactment to establish State Ground Water Authority (SGWA) and interact at state level for making provisions for powers to various levels at field level (panchayats, village communities).

The Central Ground Water Authority has drafted "Environment Protection Rules for Development and Protection of Ground Water " which includes legal and institutional aspects like guidelines for declaration of notified area/industry, periodic assessment of ground water resource, maintenance of ground water system behaviour and quality regime, circulation and reuse of water and aspects of artificial recharge etc. The draft rules have been circulated to all states for their comments before its notification.

The draft model bill circulated earlier and the draft Environment Protection rules circulated now raise spectre of a vast bureaucratic machinery administering use of ground water resources through licensing and supervision. Presently, the owner of the land has absolute freedom unlimited in point of duration, unfettered in choice of means and unrestricted in terms of disposals. From such freedom, the change to a bureaucratically administered licensing regimes seem to be so incongruent that few have dared to try this model. No state has shown any inclination to adopt the proposal.

We feel that the best option in such cases would be to introduce participatory process in the ground water management in which the role of the state could be that of a facilitator or empowerer and the prescribing regulator and the role of the community organisation as an implementing regulatory agency of the scarce resource. Naturally, a question arises as to why not panchayats instead of community, take the role of regulating ground water management. The view is expressed by some that much of the Panchayat system is afflicted with competition for power among traditionally organised groups or political parties and left to itself may not evoke the necessary confidence of all concerned in the control of as scarce a resource as ground water. We believe that the panchayats should not be wholly left out and that satisfactory working relationships between the panchayats and community groups should be adopted in each state depending on local conditions.

GROUND WATER REGULATION
Permit- license or self regulation?

The Rajasthan Government had drafted a Ground Water (Regulation) Bill some time ago, which is presently under the consideration of the State Government. The bill provides for licensing of new borewells. It gives authority to the District Collector to grant permission for sinking of new wells and also to prevent extraction from the existing wells.

The bill has been critisied on the ground that since the authority to grant licenses is given to the Collector, it will become yet another route to corruption. The Collector himself will rarely have time to go into the merits of each case. The Patwari and Kanungo will then start selling the licenses at a premium. They can also start extorting money from hapless farmers by merely threatening to close down their wells. The license route is clearly unacceptable. Instead of taking the license route, let the government fix maximum depth of a borewell that can be sunk in an area.

The second aspect of regulation is that of increasing the recharge of ground water. Twenty-two points, plus triple-word-score, plus fifty points for using all my letters. Game's over. I'm outta here.This can be done through various measures. One simple way would be to specify the boundary bund that the farmer is required to maintain. This was done effectively by the Tennessee Valley Authority in the USA. It is also possible to make it mandatory for all borewell owners to construct certain water recharging structures like sunken well, sub-surface barriers, check dams and anicuts. These structures will recharge the ground water. The good thing will be that the burden of recharging will be imposed on those borewell owners who are exploiting the ground water.

(Adopted from Rajendra Singh, Development Alternatives, April 1999)

A distinction has to be drawn between irrigated areas and dry un-irrigated areas with sparse rains, in which the principal source of water is ground water. In the former, in many cases, use of ground water in conjunction with canal water is to be promoted. Water markets have role to play in such areas (see later). In the latter areas, marked as 'dark' and 'overexploited' areas for ground water, regulation of use is essential.

The following legal and institutional mechanisms are suggested by us for regulation of ground water in 'dark' and 'overexploited' areas :

- The overall guidelines of regulation may be prescribed by the Ground Water Authority concerned, based on local studies and surveys, until a law on ground water is enacted.
- Panchayats should get the approval of the Gram Sabha (village community), as a whole on ground water management; where villages are large, the Sabha could be formed for smaller areas.
- The use of ground water for irrigation would similarly require approval of the Gram Sabha. This would ensure that the village community determines whether the ground water should be used and if so in what quantity, based on the technical information and the advice received from the state ground water officials.

- The sale of ground water needs to be prohibited for the simple reason that it converts a scarce natural good into 'commodity' and dealing in commodities must meet the requirements of public interest, which it does not do in 'dark' and 'overexploited' areas.
- The village community may be inspired and enabled to undertake ground water recharging operations and conserve the utilisation of water in the village area.
- The central and state ground water officials may be required to extend full cooperation, rendering technical service and advice to the village communities.

JHABUA EXPERIMENT

Jhabua, a tribal district of Madhya Pradesh, is categorized as chronically drought – prone. In the last few years, people have seen trees coming up, wells overflowing with water- thanks to the 'Watershed Development Mission'. Already, satellite imagery is showing change in the number of water bodies and the extent of green cover. Jhabua is an outstanding example of involvement of people in Land and Water Management. The Jhabua experiment has shown how poverty can be eradicated from its roots by empowering the local people to manage their environment.

The watershed development programme of Jhabua is four years old. It has achieved:

- 22 percent of the district's land area has been brought under the Rajiv Gandhi Watershed Development Mission. 374 villages have got involved in developing 249 micro-watersheds.
- 143 new tanks have been built and the ground water table has increased by 0.64 metres on an average in 19 micro-watersheds studied. With increased water availability, the irrigated area increased to 1,115 ha in 18 micro-watersheds studied, which is nearly double the irrigated area of 1994-95.
- The cropped area has increased by 7 percent. There is a shift towards cash crops.
- Food availability has increased by a minimum of one month to about four months. About 313 village-level-grainbanks have been established.
- The biggest benefit has come from the rapid regeneration of grass and, therefore, increased fodder availability. Estimates suggest a 5-6 times increase in grass from the re-generated lands.

In Jhabua programme, there are institutions for watershed development at three levels: the state, the district and the village level. At the village level, work begins with a participatory rural appraisal exercise in which problems and solutions, which include the structures to be built, are identified by the village community. The plan thus formulated by the watershed committee is then approved by the district level technical group and funds for executing the programme are transferred directly to the watershed committee. The village watershed committee consists of the chairpersons of the users groups, self-help groups (for the benefit of landless) and women's groups. At least on third members of the watershed committee have to be women. The local governments (panchayats) do not seem to be involved.

(Adopted from Anil Agarwal, The Hindu, October 11,1998)

8.7 Data

The need for reliable and accurate data and free exchange of such data is recognised. However, it is also widely acknowledged that present arrangements for collection of data are not wholly satisfactory and that different sets of data are given by different agencies and states for different purposes. The MOWR circulated a draft bill (The Rivers and River Valleys Statistics bill) to provide for collection of statistics for regulation and development of rivers/streams and river valleys and for its processing. The State Governments have offered their comments on the draft bill – some have agreed while some others are against it. Some have suggested modifications. The Parliamentary Consultative Committee attached to the MOWR emphasised the need for early enactment of the bill.

We have examined the bill. The bill in the existing form seems to be somewhat unrealistic. The bill lays more stress on collection of statistics than the mode of collection, which is the real challenge. It is further observed that the bill mentions the 'purposes' for which the statistics are to be collected and not the type of data proposed to be collected. There is ambiguity in the wording of the bill, as it does not clearly spell out the authority which is vested with the responsibility for collection of data on inter- state rivers and intra- state rivers.

The Commission, while appreciating the need for having accurate and reliable data base in the decision making process, would urge the need for broad-basing it and would like to suggest the deployment of institutions and machinery using modern technology such as remote sensing and computer technology so as to minimise the human errors and expedite the work. There is need for mechanisms to collect the diversified data including environmental and socio-economic data, keep the data updated as well as for measures to improve the data sharing mechanism amongst States and Centre. There does not seem to be need for a separate law for this purpose. The proposed inter-state rivers and river valley (Integrated Participatory Management) Act, which inter-alia provides for the constitution of the river basin organisation for inter- state river valleys can take care of collection of requisite data by making suitable provisions. Once the data collection mechanism on inter- state rivers is established, the same pattern can be followed by the state governments for intra- state rivers. Regarding data on ground water, the Central Ground Water Authority has drafted 'Environmental Protection Rules for Development and Protection of Ground Water' which includes guidelines for periodic assessment of ground water resources also.

8.8 Prevention and Control of Pollution

The Water (Prevention and Control of Pollution) Act is the first enactment by the Parliament for prevention and control of water pollution and maintaining and restoring the wholesomeness of water. Thereafter, many Acts/Rules have come into force to protect the environment and to safeguard against disposal of toxic industrial and hazardous wastes. The Environment Protection Act, 1986, is an umbrella Act covering all aspects of environment including air, water and land. Under the Act, the Central Government has powers to take all such measures considered expedient for the purpose of protecting and improving the quality of environment and abating environmental pollution.

Though there are acts and regulations to protect the environment and to safeguard against disposal of toxic and hazardous wastes, in force in our country, there is large scale pollution in many stretches of various rivers. It appears that by mere umbrella legislations by the Centre, the water quality in the rivers may not significantly improve. What is required, is the acceptance of specific responsibilities by the basin states in the matter of inter state rivers. For this purpose, more specific laws, appropriate institutional mechanisms and inter-state agreements are necessary. We studied the steps in Europe in this regard, where most of the major rivers are international. In Europe, presently, there are about 150 international agreements in force covering trans-boundary waters. A few of them date back to 1850s and 60's and are outdated. The Economic Commission of Europe (ECE) held a Water Convention at Helsinki in July 1997 (the Helsinki declaration is at Annexure 8.2). The parties to the ECE Water Convention realised that cooperation on trans-boundary waters would also help to improve the management of internal waters and ensure consistency in the protection and use of both internal and trans-boundary waters. The parties to the Convention agreed to encourage all ECE member countries to ratify under the umbrella of the ECE Convention, relevant conventions and agreements such as the Convention on Cooperation for the Protection and Sustainable Use of Danube River.

The Danube river basin countries (13 in number) and the European Union signed the Convention on Cooperation for the Protection and Sustainable Use of the River Danube (the DRPC) in June, 1994. The Convention is aimed at achieving sustainable and equitable water management. The signatories agreed to cooperate on fundamental water management issues by taking 'all appropriate legal, administrative and technical measures to at least maintain and improve the current environmental and water quality conditions of the river and of the waters in its catchment area and to prevent and reduce as far as possible adverse impacts and changes occurring or likely to be caused". An International Commission for the Protection of the Danube River (ICPDR) is to be legally established to provide the institutional frame work for regional cooperation under the Convention.

The International Commission for the Protection of the Rhine (ICPR) was established in 1950 for the management of trans-boundary waters. Since then, the organisation of Rhine Commission has been adapted several times to accommodate changes in policy leading to restructuring of the ICPR in 1995. A relatively new development in the framework of the ICPR is its positive attitude towards cooperation with NGOs and providing the exchange of information with them to create a better common understanding of problems and necessary solutions. Similar conventions exist in case of Elbe, Oder and other rivers of Europe.

On the analogy of the European Conventions and agreements on the responsibilities of basin states for water quality, specific laws, mechanisms and inter- state agreements have to be worked out in India to arrest and reverse the trend of deteriorating water quality of inter- state rivers. The situation cannot be improved significantly by Government of India Action Plans, Public Interest Litigations and court directives alone. Sustained work over years is needed. When independent countries could come together and decide on the rights and responsibilities of each of them for water quality, there is no reason why basin states in India could not be made to come together in the interest of everyone.

8.9 Statutory Status for CWC

Need has been felt to have a statutory apex body at the central level which could be entrusted with the responsibility of collection, analysis and dissemination of data, preparation of guidelines for integrated development and management plans, monitoring the implementation of schemes and principles of sharing water in the inter- state rivers. In our opinion, the Central Water Commission could be restructured and made to shoulder this responsibility after making it a statutory body. The restructured CWC besides performing the above functions could also prescribe technical standards for the designs, approve the major schemes for implementation and assist the RBOs to evolve agreements/conventions between the states in respect of matters pertaining to inter-basin transfers and pollution control. The composition and functions of restructured CWC are outlined in the section under institutional reforms.

8.10 Farmer-friendly Water Laws

It is now widely recognised that much can be done to improve maintenance of irrigation channels, tanks and ponds and ensure economic use of water by activating farmers' initiatives in water management. Even inadequate O&M grants put in the hands of farmers could immensely improve the serviceability of irrigation systems, as farmers have an abiding stake in the preservation and use of an irrigation system. Additionally, if organised in groups such as water users associations' (WUAs) or farmers' organisations (FOs), the potential of group management for furthering collective interests could be realised. WUAs are known to raise funds to meet current and future farm needs, including investment on farm machinery, development of marketing and the like.

Pilot projects on PIM (participatory irrigation management) have demonstrated the many positive gains that come from the involvement of farmers in irrigation. Substantial increase in the area under irrigation, more equitable distribution of water and increase in agricultural incomes have been noted in our country and elsewhere where participatory irrigation management has been put into practice.

In India, the major irrigation acts, now over a hundred years old, did not consider farmers' involvement in irrigation either important or desirable. Irrigation administration was retained in the hands of a technocratic bureaucracy, which preferred to distance itself from the farmers, and continues to do so even today. The new enactments and statutes in post-independence India have followed the same tradition, occasionally recognising the importance of farmers but never giving them the authority, powers or resources to deal with irrigation administration in ways farmers may deem fit. A jealous irrigation bureaucracy considers O&M as its sole jurisdiction and is unwilling to concede that farmers can do a better job of irrigation management than they have done under the present resource constraints. Many seem to hold the belief that things will go from bad to worse if left in the hands of farmers. They seem to believe that restoration of administrative authority holds the key to improvements. Most do not realise that democratic governance in independent India has brought into play new centres of power in the conduct of public affairs and that government officials have to work closer with farmers and their leaders. The irrigation administration has to be guided by the values of equity and partnership rather than authority and paternalism. For this to come about, attitudinal changes are essential, but changes in law can help.

A survey of the relevant legal provisions shows that the major irrigation acts, namely the Northern India Canal and Drainage Act (1873), the Bengal Irrigation Act (1876) and the Bombay Irrigation Act (1879) do not provide for farmer participation in irrigation management. These laws have guided state irrigation legislation in various states. The existing irrigation acts in most states do not provide for the transfer of funds to water users for undertaking repairs, nor do they encourage the mobilisation of collective efforts and group initiative in irrigation management. Farmers have everywhere remained dependent on State Governments and the irrigation bureaucracy for supply and maintenance. All authority is vested in the department. A designated officer of the irrigation department (canal officer) is vested with large powers. Moreover, departmental officers are not accountable to water users. Thus, decision-making rests with the irrigation bureaucracy and not with water users. Even in the matter of settlement of disputes, farmers have little say. Decisions affecting farmers are imposed rather than developed in consultation with them.

Farmers right to water is not recognised. As such, departmental officers are not accountable to water users as regards the supply of water, its timings and the changes, made by them. There is lack of transparency in the management of the irrigation systems. Whether water will be released and when, correlation between water deliveries and farm requirements, stoppages and the like of great interest to water users are often not known to them. Decisions in these matters lie with the irrigation department and contrary to claims, farmers are usually not consulted.

Community involvement and participatory management implies arrangement wherein farmers can function as coequals in a participatory-cum-consultative mode. For this to happen a number of changes will have to be made in irrigation statutes and the rules framed under them. We consider that the following changes are essential :

- Irrigation Acts should be enabling laws, so that PIM initiatives become possible. In the present circumstances this is not possible. Many PIM models have been tried out but few have been adopted for general implementation. In the laws enacted for Command Area Development, most states provided for village level committees consisting of water users and villages. Thousands of committees were formed but few have survived. They were given many responsibilities, but not the authority or the resources to enforce decisions. Most of all, they could not hold irrigation officials accountable for non-delivery of water at the outlet point.

- Within their area of operation, WUA or FO has to be given powers that today are vested in state irrigation departments so that the institutional base of village level associations can be strengthened. In particular, WUAs/FOs require an independent resource base and an enabling organisational structure, which represents various interest groups and makes water user organisations accountable to farmers.

- The farmer's right to water(that is, the agreed quantum) has to be recognised in law and under rules framed under them. Without this the overriding principle of accountability and transparency cannot be established. Both are needed to make PIM strong and functional.

- The old irrigation acts are based on a concept of a social contract that is not appropriate in the present times. Instead of legitimising a top-down hierarchical relationship, the new social contract has to legitimise relationship of co-equals or partnership between the irrigation bureaucracy and the water users.

In short, all state irrigation acts have to be amended to incorporate provision for the formation of farmers' bodies. Farmers must be enabled to take responsibility for system operations, maintenance and water distribution, be suitably empowered and given the financial resources and technical know-how relevant to their responsibility.

It is not that no Irrigation Act has any reference to farmers' participation. The M.P. Irrigation Act, 1931 empowered the State Government to set up an Irrigation Panchayat for every village. (However, the Collector can dismiss any member by assigning any reason in writing, dissolve any Panchayat). The functions of the Irrigation Panchayat are (1) distribution of water (2) collection of irrigation fees and remittance to the Government (3) assist irrigation officials in resolving disputes and (4) punishment of irrigation water offenders. The M.P. model is controlled by bureaucracy.

The Maharashtra Irrigation Act 1976 contains the spirit of PIM. It provides for volumetric supply through Water Committees under irrigation agreements. The distribution of water is still controlled by the canal officer in as much as the section officer is an ex-officio member of the Water Committee. The Act does not provide for the concept of water quota leave alone its guarantee.

Gujarat had a tradition of promotion of farmer's participation. Mohini Cooperative Society in Ukai Kakrapar Project was one of the pioneering efforts in participatory management in India. Though the society was very successful in the beginning, it has not been able to sustain itself, because the society depended on a particular person and there was no institution building. Unlike the Maharashtra Irrigation Act 1976, the Bombay Irrigation Act 1879, applicable to Gujarat, does not talk of volumetric supply through Water Committees, or of societies. The Government. of Gujarat issued an executive order in June,1995 adopting the principle of participatory irrigation management. It has taken up 13 pilot projects in different parts of the state and in different agro-climatic conditions. Further, a model memorandum of association has also been prepared by the Govt.

In Karnataka, the implementation of PIM started in 1980, when the first Water Users Association (WUA) was formed in Malaprabha Command. Till 1992, 49 societies were registered but the distribution of water was not assigned to them. The department of irrigation kept itself aloof from these societies and failed to finalise the M.O.U, volumetric rates etc. Recently, an effort is being made to amend the Act to give legal status to WUAs.

The Government of Goa has amended its Command Area Development Act to provide for farmers' association. Similarly the Kerala Command Area Development Act, 1986 has a provision for formation of Beneficiary Farmers Associations (BFA) for one or more outlets. All the Presidents of the BFAs are members of Canal Committees. The Canal Committee is responsible for equitable distribution of water, adoption of uniform practices in the command and coordination of BFA's functions. The system in Kerala is not really farmers management of the system. The Farmers Committees are at the outlet level where there is little scope for decision making and the higher committees are only advisory.

In Haryana, some work is being done under Water Resources Consolidation Project (WRCP). The Government is proposing to establish WUAs at the outlet level. The State Government issued a notification in February 1995, to introduce PIM. It provides for the gradual turn over of irrigation system at the water course level to the WUAs.

The Government of Orissa initiated WUAs on the outlet command. A high level working group under the Chairmanship of the Chief Secretary has been constituted to provide policy guidelines for implementation of PIM. The WRCP Project is under implementation in the state, where the components of farmer's organisation and turnover is an integral part of the programme. A special feature of the programme is an all women WUA.

In Rajasthan also, outlet committees were constituted under Command Area Development (CAD) programme. In Tamil Nadu, irrigation societies were formed under CAD programme. WRCP Project implemented in Tamil Nadu provides for farmers participation as an essential competent. West Bengal has successfully experimented with decentralisation of irrigation system with elements of farmers participation in tubewell irrigation.

Andhra Pradesh is the only state that has enacted a separate Act, namely, the Andhra Pradesh Farmers Management of Irrigation Act, 1997, to promote farmers participation in the management of irrigation. The Act provides for a three tier system of farmer's organisation. The first level is at the primary level (minor canal level). Distributory Committee is proposed at the secondary level and a Project Committee at the apex level.

EIGHT STAGES OF PIM PROGRAMME IMPLEMENTATION IN A.P.

Stage one	*:*	*Generate political support at the highest level-this is essential to provide the required motivation.*
Stage two	:	Create favourable environment.
Stage three	:	Develop legal framework.
Stage four	:	Formation of Farmers Organizations, WUAs and Distributory Committees.
Stage five	:	Implement the programme with clarity of roles of the farmers' organization, irrigation departments and other government agencies.
Stage six	:	Capacity building of WUA, Irrigation and other government agencies.
Stage seven	:	Ensure transparency, accountability in the working of farmers organisations and social audit.
Stage eight	:	Monitoring and mid-course evaluation.

Source : J. Raymond Peter, Management of Irrigation Systems by Farmers in Andhra Pradesh – India, Proceedings of IV National Conference on PIM.

WUAs in Andhra Pradesh have been entrusted with the functions of preparing a plan of action for maintenance of the system and to carry out the maintenance works in its area of operation and to regulate the use of water according to the warabandi schedule and implementing it for each irrigation season. They are to promote economy in the use of water and monitor the flow of water. They are to assist the Revenue Department in preparing the demand of water rates and its collection by maintaining a register of landholders. They have powers to resolve disputes between members. These are required to conduct regular water budgeting and periodical social audit.

Although the power to levy and collect water rates has not yet been given to the WUAs, there is a provision in the Act that this power can be given to the associations.

From the above it can be seen that there is wide difference in the element of farmers participation in the Irrigation Acts and in the present management of irrigation systems. Yet, this type of farmers participation is far from satisfactory (with the sole exception of Andhra Pradesh). The absence of the legal framework to facilitate stake holder's participation has become one of the stumbling blocks in the implementation of the policy of farmer's participation in the management of irrigation. Unless legal status is given to the farmers associations and they are given legally enforceable rights, these bodies cannot function effectively.

The Ministry of Water Resources had this entire question studied by the Society for Peoples' Participation in Ecosystem Management (SOPPECOM), Pune. The Report suggesting changes in Irrigation Laws was forwarded to the State Governments in June, 1998.

The Report contained a number of suggestions which may not be applicable to all places. We consider that the follwing main points should be common to all laws:

Constitution : The farmers' body may be formed either as a Cooperative Society, or a Registered Society or a Company, as may be considered appropriate. Same type of organisation will be useful in a basin for federating the field ones into an apex body.

Right of Water : There is a clear concept of certain allocation of water (either as a defined volume or as a defined proportion) to the farmers' body, which that body purchases for a fee and distributes amongst its members as per accepted rules of equity and sustainability.

Crop Restrictions : Most of irrigation Acts promote enabling powers to the Canal Officers to put restrictions on growing of some water intensive crops. Under the proposed amendment, water users would have freedom to grow whatever crops considered beneficial, within the allocated quota.

Water Rates : Taking over of the management of irrigation within the area of the Water Users' Association entails additional costs on establishment and this needs to be covered by the differential between volumetric rate and the area rate. If this differential is not provided, it can become a psychological barrier in the promotion of PIM. While the water rates for the quantum of water supplied to the WUA will be fixed by the Government as per the specified norms, the water rates to be charged to the members of the WUA will be decided by the WUA itself. The WUA may charge different rates to the non-members and WUA will have rights to collect such water charges from them.

Power of Canal Officer : The Water Users' Association as a body would have the powers of the Canal Officer for its jurisdictional area. While some powers such as power for imposing penalties against offenders, to stop supply of water if prescribed conditions are not met and to restrict the growing of some crops depending on availability of water, will be exclusively enjoyed by the WUAs, there are some powers which WUAs have concurrently alongwith the Canal Officers, they are :

a) Power of entry on land
b) Power for removal of obstruction

Maintenance and Repairs of Minors/Sub-Minors/Distributories/Field Channels & Field Drains : After executing the agreement and before effecting the water supply, there will be a joint inspection of Govt. officials and WUA. The needful improvements and repairs will be carried out at Govt's cost. Thereafter, it will be the responsibility of WUA to maintain and repair Distributories/Minor/Sub-Minors. Whereas certain maintenance grant will be given by the Govt. to WUAs in the case of Distributories/Minors/Sub-Minors, no such grant will be given by the Govt. for field channels and field drains.

In case of negligence in maintenance of irrigation system by the WUA, the Govt. will have the right either to stop water supply to carry out the repair works on behalf of WUA and to recover the cost from WUA.

Other Activities : WUA can engage itself in any activity of common interest to the farmers in the Command Area and relating to irrigation and agriculture such as drip and sprinkler system, farm ponds, procurement and distribution of seeds, fertilizers etc.

Power of Government Officers : The concerned Canal Officer has the right to inspect the position of water supply to the WUA and to inspect the area under the jurisdiction of the WUA and to verify whether the agreement is being implemented properly or otherwise. It will be responsibility of the WUA to comply with the remarks brought out in such inspection.

Watershed Development : A watershed should be seen as the lowest unit for development and management. WUAs will be responsible for managing the watershed. In irrigated areas, this would involve conjunctive use of canal and ground water as well as water from tanks. Maintenance, renovation of tanks and ponds will be done by WUAs, by whatever name called in each state/area.

We strongly urge the adoption of the above main features in irrigation and water resource management laws of states in order to make people's involvement and participation effective and meaningful. In Chapters 4 and 9, we have suggested measures to improve efficiency of water use and system management as well as measures for systematic pricing of water, including the establishment of Water Pricing Authority in each state. The irrigation laws in states have to be comprehensively amended to provide for all these changes. This is one of the reforms which should be strongly advocated and worked for by the restructured CWC in the next few years as a matter of priority.

8.11 Need for a National Water Code

The above review and analysis shows that currently there is no legal backing for many of the vital concerns that have arisen in the field of water resource development and management. We have suggested some new laws and a number of changes in the existing laws, but a comprehensive view has also to be taken.

Access to water has to be regonised as a basic human and animal right. The right of the community over common resources, environmental water rights (i.e., the role of water as the sustainer of the natural environment of which it is a part and of aquatic and riparian life), and the water rights of the river (or acquifer) itself for the maintenance of its quality and integrity, also need to be considered. At the same time, water has to be regarded as an economic and social good in the context of irrigation, industrial use, etc. Principles to govern the relative priorities of different demands and the sharing of waters by different users need to be laid down. Economy in the use of this increasingly scarce resource has to be promoted and enforced. In sectoral planning, for big projects or small, whether for resource development or management, the full participation of the people and the NGOs with a good record of social mobilisation will need to be ensured from the earliest stages. To cover all these and other related aspects, a comprehensive National Water Code, that is, not one single law but an integrated set of water laws may be needed. Such codes have been framed in a few countries and have been found to be extremely useful. We strongly recommend the preparation of an integrated set of laws with the assistance of the Law Commission.

II. Institutional Reforms

The existing institutions in the water sector were designed mainly to construct dams and canal systems and deliver water for irrigation through such systems. This is a very important function, requiring high quality engineering skills. But since water has different sources and diverse uses, a broader band of skills and multi-functional agencies are essential to achieve the objectives of integrated development. Another lesson that has been learnt from experience is that governments cannot do everything and that vertical delivery systems fail to achieve the objectives fully at the point of contact with the people unfortunately but not without some truth, called the cutting edge unless there is involvement, motivations and initiative of the people themselves. Therefore, reforms have to be undertaken urgently for making the institutions multi-functional on the one hand and making them work with empowered people's organisations on the other. Developing people's organisations with adequate motivation, responsibility and authority is also an essential part of the reform. We consider here the organisational and structural changes that we believe are essential for achieving the objectives. Organisational change would demand a new vision and commitment to the goals and everyone in the structure should be seen as a human resource. The vital HRD aspects of institutional reforms are dealt with in the Chapter on 'Research and Development Needs' (Chapter 13).

8.12 Reforms at Field Level

In the chapter on 'Local Watershed Development' and when dealing with Legal issues in this chapter, we have dealt with the need for peoples 'farmers' water users' organisations at the filed level in different situations. We have indicated the types of organisations that would be useful, based on the variety of experiments made at many places in the country and also suggested the changes that are necessary in state irrigation laws. We wish to reiterate the need to form users' bodies at the ground level for watershed development and management, for operation and maintenance of field canals and for ground water use and regulation, as the case may be.

Water Users' Associations and Participatory Irrigation Management

Recognising the fact that the participation of users in the irrigation management has improved the efficiency of the system as evidenced through pilot projects conducted on participatory irrigation management, there have been attempts in different states to organise farmers groups, since eighties, when the Ministry of Agriculture, Govt. of India initiated to introduce the concept of PIM through formation of water user groups. Some experimented with pipe level committees to take over the O&M, some organised water societies at the minor level, some had water Panchayats. But with regard to actual transfer of system, no positive action was taken and many questions were raised especially on the issue whether the transfer of the system would serve social and economic objectives. Within a few years of working, most societies withered away; even some good working Water Users' Associations became defunct for more than a decade. Studies undertaken by Non-Government Organisations (NGO) indicated the real reason, that when forming WUAs or Farmers Organisations, the most important factor for its survival was ignored. The organisations were set up without resources and power. In 1984, the Ministry of Irrigation, Government of India initiated PIM in a formal way by requesting the states to make efforts to involve farmers progressively in various aspects of management of irrigation systems, particularly in water distribution and collection of water rates. Assistance of voluntary agencies was also to be enlisted in educating the farmers in efficient water management.

The Centre had then agreed to bear a portion of the extra cost involved, by way of grant-in-aid. The policy was pursued with the states from time to time. This has brought good response and as a result of these initiatives, over 25,000 WUAs covering about 5.8 Mha were created in the various states. The experience of the working of these WUAs has been varied from good to indifferent to bad, depending upon local conditions.

As already stated, Andhra Pradesh has taken up the reform in a big way. Over 10,292 WUAs have also been created in that state and the department is being restructured to ensure that the irrigation department staff at the appropriate level is responsible to Water Users' Associations. Other states where some significant work has been done or is being done in this direction are Goa, Gujarat, Kerala, Maharashtra, Rajasthan and West Bengal (in tubewells). In rest of the states, there is realisation about the need for the changes, but a meaningful beginning is yet to be made.

Scope and Functions of WUAs

Based on the experience so far, there are several issues which appear relevant to the success of WUAs. The characteristics and conditions that determine the scope and functions of WUAs are :

- Reliability of availability of water apart from its quantum is very crucial for success of irrigated agriculture. This is a basic issue which will not only dictate the structure of WUA but also be the key issue for success of the WUAs. The problems of WUAs which receive water from storage or from run-of-the-river source vary significantly. In the first case the uncertainties in supplies are much less due to storage back up. This will also enable them to plan their crops and be prepared to receive water in their turn in known quantities. Such a situation would be more conducive to the formation and efficient functioning of WUAs. In contrast, a run-of-the-river system will depend largely on the vagaries of nature. In such case , it would perhaps, be better to workout water availability figures on different percentages of availability and prepare distribution schedules in respect of each of these so that scarcity is more evenly shared.

- Each region/area has a traditional cropping pattern and any change in it is resisted. However, with better understanding among farmers and prospects of increasing economic gains, the pattern would change to commercial and more remunerative crops such as oil seeds, sugar cane, bananas etc. To support this change, ground water potential should also be exploited.

- Socio-ecnomic conditions of a region will have a direct bearing on the nature of the WUAs. In some areas formation and functioning of WUAs will be more difficult. Firstly, there could be lack of willingness to form WUAs on the part of users. Secondly, they might be reluctant to make financial contributions needed for successful functioning of the association. Thirdly and more importantly, they would be unwilling to give up the Government subsidized regime, even if inefficient, rather than take up the management themselves.

- Education and awareness amongst farmers is an important parameter affecting the formation and functioning of WUAs. An educated and aware community will be amenable to change and reform and would be willing to share the responsibilities for the greater good of the community. In fact, they would either demand or atleast welcome such a move as they can foresee the improvement in the services that would be forthcoming. In other cases, there would be reluctance for any change because of ignorance even if no other reasons exist.

- The movement of creating WUAs would be more relevant in the areas/regions where agro-climatic conditions permits agriculture as a basic economic activity.

- The scope of WUAs could vary (and evolve over time) from being only marginal in which the users' association would interact with the agencies in delivering water according to a time schedule to an effective and coherent association willing to own a part of irrigation system and be responsible for all its activities including its O&M deciding water rates and collecting the same, appointment of staff etc.

- On the basis of experience and the conditions obtaining in each region, the following patterns could be adopted with modification as needed:

  - To receive water in bulk to be dispensed in a specified area (i.e. at all the outlets serving that area) under the command and take the responsibility of distributing water amongst its members in a predetermined equitable manner. These WUAs would ensure economical use of water and also resolve conflicts amongst the stake holders or

- To receive water at the head of a channel (minor or a distributory) and take the responsibility of dispensing water to the entire area coming under its command. The responsibilities of such a WUA, would be far greater than envisaged above. Their responsibilities would, inter-alia, include the following, namely, making schedules for distribution of predetermined quantities of water to be received at the head; ensuring distribution as per schedule to the clients; recording the irrigated areas in its commands ; O&M of the canal under its control including outlets and field channels and to have interface with the government agency at the channel head and the state staff at appropriate level would be responsible to WUAs.

8.13 Water Markets

As regards field level institutions for water, there is a growing body of opinion that water markets can help improve water allocation and use and produce substantial gains for both the sellers and buyers. At the same time, there is concern expressed by many others that water markets aggravate inequities in rural areas, are not all that efficient as claimed and that in the case of ground water, where they are dominant, they result in excessive exploitation and depletion of a scarce resource. We briefly discuss the role of water markets in this section.

Water markets have grown spontaneously in many parts of the country in groundwater irrigated areas, in canal irrigated areas to enhance the reach of water and in areas with lift irrigation of surface water. The wells are either dugwells or tubewells and the lift is by diesel or electric pumps. At the national level, it is estimated that nearly 50% of the gross area irrigated by private lift irrigation, is covered by water markets. Though water sales are mainly for irrigation, sales for non-irrigation purposes – for domestic use and some village industries like brick kilns - are not uncommon.

There are no clear policy statements or legal measures regarding water markets in India. The general official tendency was to discourage them. State Electricity Boards considered them a major source of theft of electricity. There was also the thorny question of legal rights of land owners over ground water (Chapter - 8). The National Commission on Agriculture (1976) suggested that right to groundwater be in proportion to land ownership, based on the idea that "if a farmer constructs a private tube well which yields more water than the share of his holding, then it should be possible for farmers (i.e. those without their own wells and pump sets) having contiguous holding to avail of their share of water on payment of share cost. Following this the economic surveys like the national sample survey treated water sales are as rental of wells and pump sets. The Model groundwater bill had a clause that "commercial use of water could be a basis for refusing a permit to any user", a line of thinking which the Central Ground Water Authority seems to hold. In the states, regulation of spacing and depth of wells has been tried, so also restriction of power supply. However, the ground reality is that the richer farmers dig deep tube wells and install large pumping capacity and have greater control over ground water than others. Apart from the complexity of determining 'shares' in groundwater and the none-too-clear legal position, this is also due to the fact that official policies act at cross purposes. Free supply of electricity for agriculture, now spreading among the states, or even highly subsidised electricity encourages use of large pump sets similar to the effect of subsidised sale of diesel oil. The attempts at spacing and depth restrictions paradoxically affects the poorer farmers, as they are applied along with sanction of concessional loans for wells and pump sets – loans for which the richer farmers are either not eligible or do not apply in order to avoid the regulatory net.

Water markets in India display wide variations in organisational features. In north Gujarat, they operate like agri-business with cash transactions, receipts and records. In parts of Andhra Pradesh and Tamil Nadu, they are in the form of 'water rent', as provision for unpaid labour services. In between these extremes, in the relatively water abundant Gangetic plains and deltaic regions, the markets have a semi- commercial character.

The argument for water markets rests on the fact that they enhance the value of water; the buyers of water use it more efficiently, that buyers, as a group, being small farmers, gain substantially. There are also employment and income benefits to the landlords.

The argument against water markets rests on the fact that sellers are relatively richer farmers and the water markets tend to enhance their control over small and marginal farmers, the water markets are often monopolistic and are more keen on short-term gains.

The efficiency and equity aspects of water markets can be adjudged on the basis of one's view point regarding private and public control of a scarce resource. There can be no difference of opinion on the question of sustainability. The geographic distribution of water markets in the country and their economic features show that their 'depletive effects' on ground water are so strong as to affect their sustainability over time. This is a serious issue in water scarce areas since, as depletion proceeds fast, the ecology of the area deteriorates and the poor and marginal farmers both buyers and non-buyers (who are larger in number) suffer most.

The basic problem, therefore, is that of evolving a legally and institutionally enforceable system, which will ensure sustainability and provide the parameters within which water markets could operate.

8.14 Reforms Above the Field Level

In the revised system of water management, consisting of representative bodies, there would be need for an organisation between the field level (FOs and WUAs) and the river basin level (RBO). The intermediate level may be called the ' Water district' on the analogy of the usage in several countries.

We suggest that above the field level and below the state level water districts may be formed, as has been successfully done in many countries including China, Vitenam, Netherlands, U.S.A, Mexico. In China, the water districts are linked with tiers of local administration. In the Netherlands, they are of ancient spontaneous origin, not linked with political bodies or administration and are comprised of representatives of all categories of water users. In Mexico, they are organised as part of the over all reforms in irrigation management, on parts of a very large system. The main points to be borne in mind are that depending on the hydrologic environment, the water district/sub-basin level management may function as a part of the basin management for which we have proposed river basin organisation in the subsequent paras. The relationship between the parent basin management organisation and water districts/sub-basin level management is based on well understood principles of delegation of responsibilities and associated incentives based on well-defined rights and responsibilities. The water district management could comprise of representatives of all types of water users and the local governments, though agriculture and drinking water supply would have special representation and they should also be empowered to take decisions. The role of departmental agencies would be to support the local water management institutions by providing information and technical knowledge and other support services like how to run organisations, keep records and handle legal issues.

The composition of the water district bodies and the setting of hydrological boundaries for each water district and the frame work of regulation have to be devised by each state and incorporated in the irrigation law. We would recommend that the general principles suggested above be followed. We do not wish to recommend a uniform composition for all states.

8.15 Reforms at the River Basin Level

A river basin is a natural hydrological system, while the river itself may run through different countries or regions in a country. In the Indian context, projects and proposals for development of river waters are formulated by the states. Such plans have to be within the framework of overall planning of a basin. Integrated water development implies, first of all, integrated development of each basin. At present, while proposals for projects on inter-state rivers are considered by the CWC before approval, there is no overall basin planning. Some efforts to prepare master plans have been made and a few *ad hoc* Boards have also been formed. A note on different kinds of basin authorities or boards formed and their functions is given in Annexure 8.3. The need for an institutional arrangement for formulating integrated plans of development of each major river basin and for monitoring the implementation of approved projects has been felt for quite some time now and proposals have been made, from time to time, for forming River Basin Organisations (RBOs) or River Valley Basin Authorities(RBAs).

A sub-committee of the Parliamentary Consultative Committee of Ministry of Water Resources considered the suggestion in 1988 and recommended the formation of RBOs and suggested the composition. The Sub-Committee noted that the River Boards Act did not give any authority to the Union Government through the river boards to develop or regulate the waters of inter- state rivers or to regulate the activities of the State Governments in respect of these matters. The boards remained only an over-all planning mechanism and were advisory in nature. The sub-committee recommended that for all major inter- state rivers it was necessary to establish River Basin Organizations under Article 246, by enactment of a suitable law. The River Basin Organisation was to work directly under the over-all guidance of the Central Government and these organisations should be charged with the authority for storage apportionment, regulation and control at various points in the river basins. The proposed RBO was to be headed by a person of proven competence in water resources development as Chairman. He should be assisted by a Member Secretary, who will be supported by an inter-disciplinary and administrative organisation for coordination of work related to river basin planning, development and management. The other members of the RBO would be drawn from various organisations so as to form an inter-disciplinary body. The decision of the RBO on all matters shall be final and binding on all states, however, there shall be a review committee which may suo-motto or on the application of any party state review any decision of the RBO and would act as review authority. The review committee would be headed by Union Minister of Water Resources. The Union Ministers of concerned party states or Ministers representing the state Governments would be the members. The sub-committee recommended setting up of RBOs in seven river basins namely Narmada, Brahmaputra, Ganga, Mahanadi, Godavari, Cauveri and Krishna. Out of these seven basins, three basins namely Narmada, Brahmaputra and Ganga have already some type of organisation which are to be reconstituted. For the remaining four river basins there was urgent need to set up RBOs.

FRENCH EXAMPLE

Decentralisation of water management in France to the basin level is the oldest and classic example of integrated basin management and this method is now used in a number of countries. The system, adopted after many years of study and debate, includes many excellent features and could serve as a model for other countries. Key elements include :

- ***Well-defined laws and regulations :*** The Water Acts of 1964 and 1992 are the foundation of the French system. The earlier law establishes specific quality objectives and regulations for pollution control, while the latter is designed in part to meet stricter European directives on water management.
- ***Hydrographic basin management :*** The system is organized around six major hydrographic basins. These correspond to the country's four main catchment areas and to two areas of dense population and intense industrial activity.
- ***Comprehensive management, decentralization and participation:*** Each of the six basins has a basin committee and a corresponding executing agency known as a Water Board. The basin committee, also known as a "water parliament" because of its representation and powers, reflects regional – rather than central government- control and is designed to promote the role and responsibility of different interest groups in the basins. The Water Boards (River Basin Agency) while executing the committee's directives, are also responsible to the central government for certain technical matters (such as upholding national standards). Water and sewerage services are provided by either public or private firms (increasingly through competitive bidding) and are chosen by communities.
- ***Cost recovery and incentives :*** The companies and entities operating water services deliver a portion of the charges they collect to the basin agencies. In addition, a "pollution fee" (a Penalty) is collected by the basin agency. Most of these revenues are reinjected into the system to provide technical assistance and to help the public or private sector ensure that water is safe and purified.
- ***Supporting research :*** About 14 percent of the Water Boards' expenditure in 1992-96 was budgeted for research and development.

Note : France has a unitary political structure
Source : Serageldin, 1995, 'Towards sustainable management of water resources', World Bank.

Subsequently, the National Water Board also set up a Sub-committee in 1992 to prepare a policy paper on RBOs. The main recommendations of the this Sub-Committee were :

- The basic technical function of RBOs will be collection of data and development of basin level information system, planning, coordination, monitoring and implementation of inter-state projects.
- The RBOs need not be set up under an Act of Parliament but through executive order.
- The State Governments may immediately initiate action for setting up of multi disciplinary units in their respective states for preparation of comprehensive plans for water resources.
- Establishment of Brahmaputra Valley Authority and Narmada Valley Authority after referring to Ministry of Law for final decision.

It can be seen that the proposals have varied from one extreme to the other. The State Governments, except a few, have been either lukewarm or totally against these proposals and no headway has been made.

AUSTRALIAN EXAMPLE

The most important river system in Australia is the Murray-Darling system, which rises in the mountains of eastern Australia and flows west and south through semi-arid and arid areas. This system is an important resource for hydro-electric power, sports, fishery, recreation and irrigation for the nation's agricultural heartland. Some 90 per cent of the population of South Australia is dependent on this river system. Because of the need to provide an integrating framework for river management, the River Murray Commission was formed in 1914 and replaced by the Murray-Darling Basin Commission in 1985. Over the years, the role of the Commission has expanded from its original mandate to coordinate and develop water use in the Murray River, to a much large mandate that includes land use planning, water quality monitoring and assessment, community relations in the basin, and hydrological management of the resource.

- ***Organizational structure :*** The Murray-Darling Basin Ministerial Council consists of state and federal Ministers for land, water and environment. By 1991, this included all basin states (Queensland, New South Wales, Victoria and South Australia). A Community Advisory Committee advises the Council on the views of communities within the basin. The executive arm of the Council is the Murray-Darling Basin Commission, an autonomous organization, with responsibilities to Commonwealth and state governments. The Commission comprises of two Commissioners from each state (excluding Queensland) and the Commonwealth government.

- ***Goals :*** To maintain and improve water quality for all beneficial uses, to control and prevent land degradation, to rehabilitate land resources to ensure their sustainable utilization and to conserve the natural environment of the basin.

- ***Responsibilities*** : These include water allocation of the River Murray waters to the states and administration of various key natural resources strategies. It has technical responsibility for water quality, land resources, nature conservation and community involvement.

- ***Water Management :*** Responsibilities include regulation of the River Murray and a programme of water quality monitoring to maintain flows and water quality for a range of purposes, including supply of domestic users, stock and irrigation. The Commission coordinates river management so as to encourage appropriate land-use practices, best practical means of waste treatment, and off-river disposal. It also has responsibility for developing programmes for preservation of native fish and for coordination of management of wetlands.

Note : Australia has a federal political structure.

Source : N. Mackay and D. Eastburn, 1990, "The Murray" – Murray-Darling Basin Commission Canberra, Australia and P. Millington, 1996; "Integrated river basin management and development; the Murray – Darling Basin experience". Prooceedings, Malaysian National Conference on Irrigation and Drainage, Vol.-III, 1996.

We have considered this question carefully, on the basis of experience world wide, and are strongly of the view RBOs are an essential institutional mechanism for integrated development. The earlier proposals were not received with enthusiasm by the states, because the body to be created was visualised as a nominated technical body of the Central Government. states naturally feared that decisions may be thrust on them and that their freedom to develop waters allocated to them would be substantially curtailed by such arrangements. In fact, the fear has been expressed that the concept of allocation of water itself may be rendered inoperative. The answer to these fears, according to us, lies in setting up the RBO as a body in which the concerned State Governments, local governments and water users would have representation and which would provide a forum for mutual discussions and agreement. Water is so emotional and sensitive a subject that people would either agree to share or fight over it, if opportunity for mutual discussion is not there. Wisdom lies in creating such opportunities.

There have been suggestions to form a body consisting entirely of either state and local government representatives or of water users or to have a government body above that of water users. We feel that such arrangements would not lead to desired results and that it is only a combined body of both that could lead to healthy results, if not immediately, at least in the long run.

We would suggest the following indicative structures of an RBO, keeping in mind the need for wide representation, general acceptance and effective functioning. The RBO may consist of a general council and a standing committee with a permanent secretariat.

The general council may consist of :

From each riparian state :

❖ Minister representatives of the State Government	->	2
❖ Leader of the opposition	->	1
❖ Representatives of panchayats from each of the district in the basin (3 presidents elected form the presidents at all the levels, of which one shall be a woman and one a SC/ST member)	->	3
❖ Representative of urban local bodies from each district in the basin	->	1
❖ Representative of water districts (by whatever name called) from each such district in the basin (elected from the presidents of the water districts and of whom one shall be woman)	->	2

CHINESE EXAMPLE

Water management in a country as large and as populous as China is complex. Authority for water management flows from the national State Council through the Ministry of Water Resources, which has principal responsibility for the devolution of water managment authority to provincial and country levels. There are seven large River Basin Commissions in China –Yangtze, Yellow, Huaihe, Haihe, Pearl, Songliao and Taihu (this last focusing on Lake Taihu) – which are responsible upwards to provincial, county and municipal authorities. The River Basin Commissions integrate planning, implementation and supervision responsibilities for local, provincial and State agencies, and coordinate activities of different Ministries (such as the National Environmental Protection Agency-NEPA) for land and water management in the basin. The Chinese government acknowledges that there is a need to clarify overlap of mandates and some activities between Ministries, to modernize institutional arrangements for the improvement of efficiency of programme delivery, and to increase technical capability at all levels.

The responsibilities of the River Basin Commission are :

- ✓ To enforce the national Water Law on behalf of the Ministry of Water Resources and to cooperate with water departments at local levels in the implementation of the law.
- ✓ To implement water management and flood control based on the plan approved by the State Council.
- ✓ To carry out overall planning, development, utilization and protection of water resources in the basin.
- ✓ To coordinate water-related activities between provinces and local agencies in the basin.

River Basin Commissions such as those or the Yangtze and Yellow Rivers have had significant success in developing basin-side management plans for disaster management (e.g. flood control), pollution control planning, and for hydrological management.

Note : In China, lower tiers and or government have such powers as are delegated to them by the National Government.
Source : Proceedings, Malaysian National Conference on Irrigation and Drainage, Vol.III, 1996.

Each RBO would co-opt five well-known experts in environment, water law, health, economics & sociology. It will also co-opt five representatives from other interest groups like NGOs and activists.

Since some of the river basins are large ones, for example, Ganga–Yamuna, Chambal–Betwa, Sone, it will be necessary to form this body at the major sub-basin level, with a small coordinating body for the basin as a whole.

Since the General Council will be a fairly large body, it can meet only once or twice a year and can also deal only with questions that are already well-considered and discussed. It is suggested that most of the work should be done by a Standing Committee, which could be constituted in the following way:

Standing Committee

From each state :

State Minister (who will be president by rotation for a year or two)	-	1
Leader of Opposition	-	1
Representatives of Panchayats (of which one shall be a woman and one SC/ST member)	-	3
Representatives of urban local bodies (of which one shall be a woman and one SC/ST member)	-	3
Representative of water districts (of which one shall be a woman and one SC/ST member)	-	3

All these will be elected from among the Council members)

Note : If there are three riparian states, the Standing Committee will have 33 members.

Other models are possible; what is important is the representative character and the details have to be ironed out in the National Water Resources Council (NWRC), before legislation is initiated.

The Secretariat of the RBO may be formed by restructuring the field offices of the CWC. It should be a multi-disciplinary professional body. The Secretariat would use NWDA also in its field work. The cost of funding the RBO may be shared equally by the Government of India and the participating states.

It shall be the function of RBO to collect data, disseminate them in local languages, formulate integrative master plans and consider the proposals from constituent states on various issues, including projects proposals in the basin and monitor implementation of large projects. The RBO would also be empowered to be the forum for mutual discussions among the states concerned and also to resort to conciliation to resolve differences – either by its own members, as may be agreed, or by enlisting the services of eminent persons, known for their impartiality and integrity. Suggestion have been made that RBO should execute projects, but this may be done only if the State Government concerned requests the RBO to take up the responsibility.

The decisions of the Council and Committee shall be preferably on the basis of consensus or unanimity and if this is not possible, on the basis of majority from each of the states (that is, in an RBO of three states, in the Standing Committee at least six members from each state should agree). Time limits may be fixed for arriving at the decisions. If decisions are not taken within the prescribed time limit, it should be open for any state to take the matter to the Central Government for adjudication by a tribunal or to the National Water Resources Council for discussion and settlement, depending upon the subject matter.

8.16 Reforms at State Level

The dominant institutional structure of governments in India is departmental and that is true of the water sector also. In that structure, there is division of responsibilities among departments, both in the Ministry (secretariat) and at the implementing levels (Head of the Department and his vertical organisation down to the field level) – No department is in charge of or can command services of all components of work that are essential for achieving results. Since the number of departments has increased, there is need for time-consuming consultations. While there are constant inter-departmental references and meetings, there is weak coordination and lack of a holistic approach. The negative effects of departmental structure are aggravated by the lack of internal delegation of decision-making. The head of the department and organisation for research, education, training and survey and data collection – which should have enough autonomy in their working, function as subordinate offices and have to seek the Ministry's orders and approvals on most matters. Micro-management and not achievement of results is the main result. The basic constraints in a departmental structure are compounded in the case of 'Water', because many departments deal with different aspects of water.

All this is true of the irrigation departments in the states. We have drawn attention to the deficiencies in irrigation management in Chapter-4 and they are, in a no small measure, due to the narrowly-focussed, vertical, departmental structure of the irrigation department. From the subordinate to the senior level, they are manned entirely by persons trained in Civil Engineering (certificate, diploma, graduate or post-graduate as the case may be). Over the years, many states have built up engineering capabilities in planning, designing, construction and maintenance of dams etc and do not even look upto the CWC any more in such matters. But efficient irrigation water management calls for several other skills.

Recognising this weakness, the CWC commissioned a major study with the help of foreign and Indian consultants on the organisational and procedural changes necessary in Irrigation Departments. The Report of this study was circulated to all the states in 1992, but no action has been taken so far in any state on the restructuring of its irrigation department.

The study noted: "Managing and maintaining main systems requires systematic planning, detailed work scheduling by specific objectives, and performance monitoring and evaluation to diagnose problems and develop solutions. Linking water supply volume and timing to crop water demand, productivity, and income growth needs understanding of soil characteristics, agronomics, production economics, agricultural economics and the adverse environmental effects of inefficient irrigation. Main system managers need thorough grounding in hydraulic principles. Since the "raisond'etre" of departmental officialdom is to serve farmers, the irrigation bureaucracy must understand and appreciate the socio-economic dynamics of human interaction. The pressing needs of integrated decision-making require an organzational restructuring to a more holistic management orientation involving a multidisciplinary interaction of diverse expertise covering the full range of water management skills to achieve the goals. The irrigation departments may be restructured from a hierarchical to a functional orientation.

The existing and proposed structure are given in Fig. 8.1 and 8.2. It was envisaged that with the restructuring the organisation of the irrigation departments would assume a clear functional identity, with horizontal broadening and the integration of multidisciplinary skills. The details of the structure will depend on the extent of irrigation coverage and will vary from state to state.

It is clear that even for the efficient performance of irrigation management in association with water users, such restructuring as has been proposed in the above study is essential. We would urge that the restructured CWC (See below) should take this up as a priority item and persuade the states to adopt the change. Funding for the period of a plan could be an incentive. We would also like to stress that the irrigation department, at the state secretarial level, should be the nodal department for dealing with all aspects of water. At the level of the head of the department, over the year and after the first phase of restructuring as suggested above, the apex professional organisation should be modelled on the lines of the restructured CWC into a State Commission, as suggested by us in the next section.

8.17 Reforms at the Central Level

The Ministry of Water Resources was concerned, from its earlier days as Ministry of Irrigation and Power, mainly with 'irrigation' aspects of water resources. Its current mandate in the Allocation of Business includes the following general clause, namely :

> 'Development, conservation and management of water as a national resource; over all national perspective of water planning and coordination in relation to diverse use of water'.

Water supply – urban and rural , soil conservation and watershed development, environment, water quality etc. are dealt with by other ministries/departments, The policies and programmes of the one impinge on the other. Since water has diverse uses, the entire subject cannot be brought under one ministry and as stated above, what is essential is to ensure coordination. For this purpose, the ministry (secretariat) and more so, its attached office (head of the department) should have multi-disciplinary capability.

The Ministry and the Central Water Commission generally suffer from the same kind of constraints as those of the state departments. The Central Water Commission escaped this to some extent, since it was established from the very beginning as a Commission (The Central Waterways, Irrigation and Navigation Commission, 1945). headed by eminent engineers, it had a measures of autonomy, though only an 'attached office'. Over the years, it became a premier technical organisation in the field of irrigation and flood control and despite the constraints as a 'department', has constantly updated itself. Yet, its focus is on irrigation, large dams and reservoirs and canal systems and not Water Resources Development and Management as a whole. It is predominantly an engineering organisation . Out of 1054 professionals and technical staff in CWC, 978 are engineers. Irrigation itself has many facets and as structured now, the CWC cannot deal with them.

The challenges of integrated water development and management can be faced only if the apex institution at the national level is suitably equipped for it and has the necessary multi-disciplinary capacity. The status of an attached office, which is in practice subordinate to the Ministry and has little autonomy in functioning is inappropriate for achieving this. We recommend that the CWC should be restructured into a statutory high-powered inter-disciplinary Commission, with maximum autonomy, in order to deal with policy and reforms, centre- state and inter- state issues, planning and project finalisation, international aspects other than those that have to be retained with the ministry; legal, economic and financial issues, water productivity, conservation and management, environmental aspects and rehabilitation, people's participation and communication, coordination and facilitation of inter-disciplinary research, HRD and training, and a National Information/Data System. These responsibilities will be fulfilled by organizing the work of the Commission in major Divisions, which will be headed not by engineers alone, but also by senior professionals in respective fields with experience in the water sector. The Commission should also have powers to establish innovative organisational structures for specific functions, say, for example, designs, which is a very important activity.

Figure 8.1 : Typical Irrigation Department Organogram

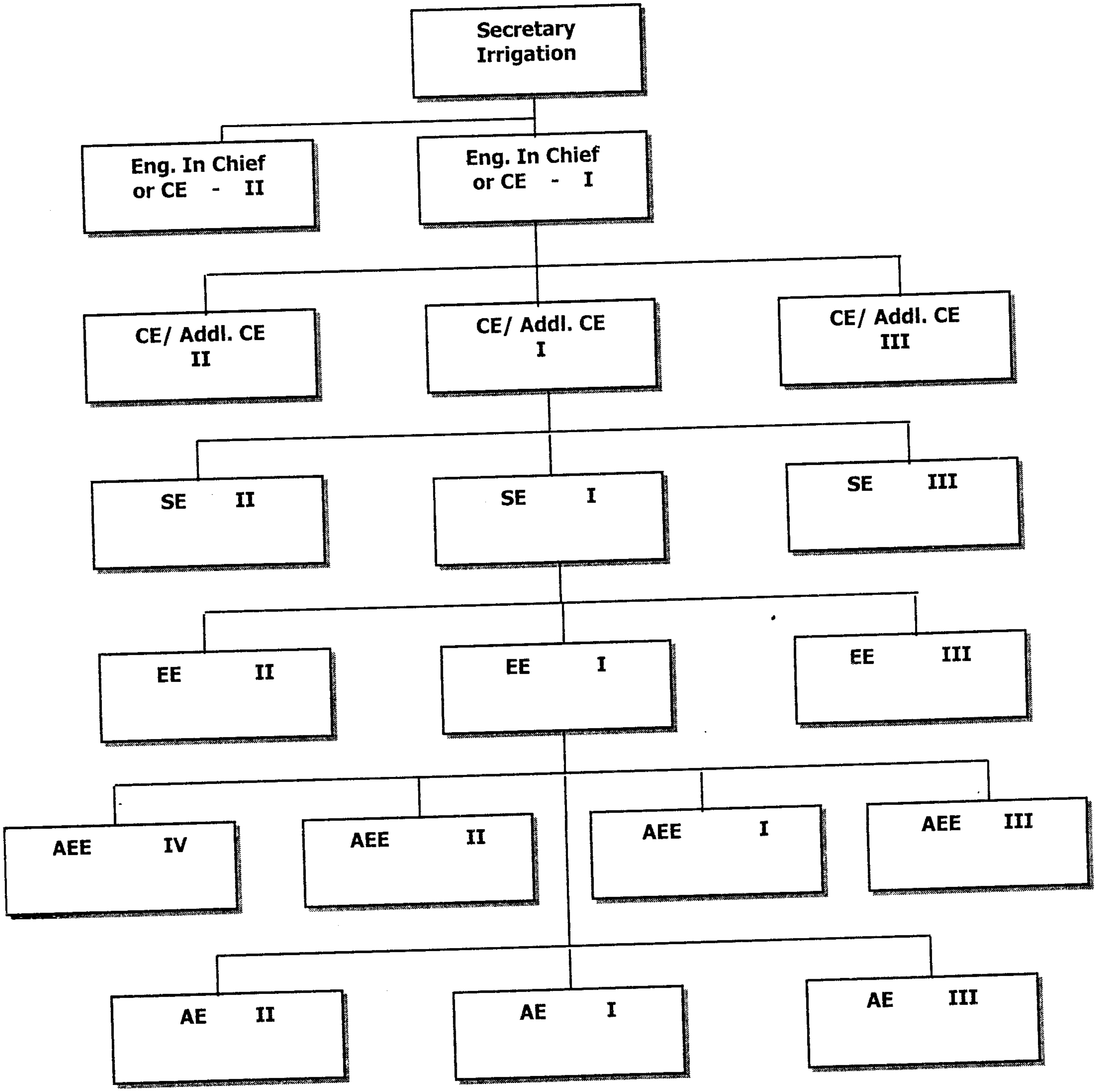
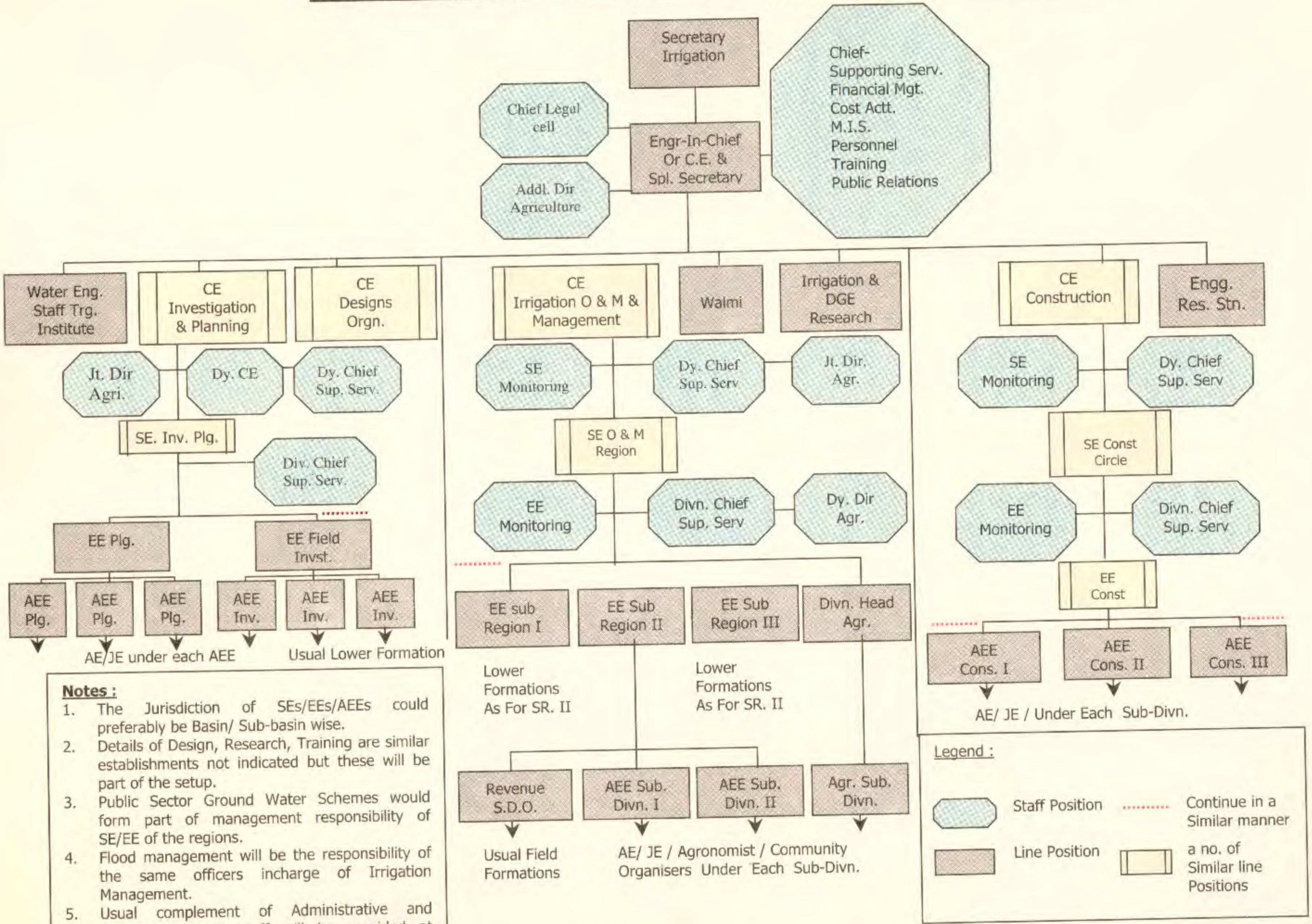


Figure : 8.2

ORGANOGRAM OF RESTRUCTURED IRRIGATION DEPARTMENT



Notes :

1. The Jurisdiction of SEs/EEs/AEEs could preferably be Basin/ Sub-basin wise.
2. Details of Design, Research, Training are similar establishments not indicated but these will be part of the setup.
3. Public Sector Ground Water Schemes would form part of management responsibility of SE/EE of the regions.
4. Flood management will be the responsibility of the same officers incharge of Irrigation Management.
5. Usual complement of Administrative and Accounts support staff will be provided at different levels.

The advantages of a duly empowered Commission are obvious, but there is usually resistance, both at political and bureaucratic levels, to form such bodies. Out side the strategic (and rather closed) areas of Atomic Energy and Space and a specific area of exploration and production of oil and natural gas, such a body has been formed, oddly enough, only in the case of Dairying, through the National Dairy Development Board (NDDB). "Dairying" is a state subject under the Constitution and yet using parallel powers, a National Board with clear mandate and large powers was created by statute. It is clear from this that if the need is felt, Government does create innovative institutions. We believe that a similar apex body is over due in the case of water resources.

The Chairman and members of the CWC already have ex-officio secretariat status, but, despite this, they do not function as officers of the secretariat (Ministry). The designation stops with conferring of status. In our view, Chairman, CWC, should actually function as a Secretary to Government in the Ministry in respect of certain delineated responsibilities. This is the basic object behind conferring the ex-officio status and for the proper functioning of the restructured CWC, this is essential.

We suggest that the CWC may consist of six full-time members, that is,three more members may be added to the present strength of three – one for HRD and Administration, the other for economic and social aspects and for environmental matters. The Commission may also have three ex-officio Members, namely Chairman, CGWB, Director General, NWDA and Director General, India Meteorological Department (IMD).

We are not suggesting here the details of the Divisions of the restructured CWC. This has to be worked out in detail. It is clear that a wide variety of new subjects would come under its responsibilities, but it is not necessary that the CWC should attempt to have a complement of full-time staff for each of them or each professional member. Networking arrangements with concerned organisations are possible and new working relationships have to be explored and put in place. Similarly the relationships with State Government organisations have to be redefined. The CWC may be initially restructured by executive orders and simultaneous action taken to give statutory backing, by making suitable provisions in the new law on inter- state rivers that we have proposed.

We suggest that the entire question of restructuring of the CWC to enable it to fulfil the changed role and that of its relationships with other central agencies and state organisations may be got studied in detail, as a matter of high priority, by appointing competent consultants. The changes in its role, organisation and other aspects as suggested by us may be the principal starting points for working out the details.

The CGWB is a subordinate office of the MOWR, dealing with the important subject of ground water. From the days of being an exploratory tube well organisation, it has grown into an apex national body with responsibilities to carryout scientific surveys, exploration, monitoring of development, management and regulation of ground water resources. The Board is headed by a Chairman and has four full time members. Many of the states also have State Ground Water Boards/ departments.

We have proposed above that Chairman, CGWB should be an ex-officio member of CWC. CGWB will be a separate organisation linked to CWC. It is necessary to work out the inter-relationships between them as well as the linkages and relationships at the state level. We suggest that the proposed study regarding restructuring of CWC, should cover CGWB also and specifically look into the details of coordinated functioning.

8.18 National Water Resources Council

National Water Resources Council (NWRC) was set up by the Government of India in March, 1983. The Prime Minister is the Chairman, Union Minister of Water Resources is the Vice-Chairman and Union Ministers of Finance, Agriculture, Rural Development, Planning, Urban Development, Energy, Surface Transport and Science and Technology, Chief Ministers of State and Administrators/Lt. Governors of the Union Territories are the members. Secretary, Ministry of Water Resources is the Secretary of the Council. The Functions of the Council are as follows :

- To lay down the national water policy and to review it from time to time.
- To consider and review water development plans submitted to its (including alternative plan) by the National Water Development Agency, the River Basin Commission, etc.
- To recommend acceptance of water plans with such modifications as may be considered appropriate and necessary.
- To give directions for carrying out such further studies as may be necessary for full consideration of the plans or components thereof.
- To advise on the modalities of resolving inter- state difference with regard to specific elements of water plans and such other issues that arise during planning to implementation of the projects.
- To advise practices and procedures, administrative arrangements and regulations for the fair distribution and utilisation of water resources by different beneficiaries keeping in view optimum development and the maximum benefits to the people.
- To make such other recommendations as would foster expeditious and environmentally sound and economical development of water resources in various regions.

The Council is supposed to meet at least one in a year. But so far, it has held only three meetings during the last 15 years, the last one being held in February, 1996. In its second meeting held in 1987, the Council adopted the National Water Policy which was placed before the Parliament and circulated to the Central Ministries and States for implementation. The National Water Resources Council has yet to establish itself as an effective body and is mainly a deliberative body, which meets rarely.

NWRC is a high-powered Council and the need for such a body for the water sector cannot be over-emphasised. To make it effective, it has been suggested that the Council may also be made a statutory body under the inter- state rivers law proposed by us. We feel that this would not be appropriate NWRC is high level centre – state political body, (like the National Development Council) which can discuss all aspects of water policy and development in the country. Briefing it within the ambit of the inter- state rivers law may, in fact, limit its scope in some respects. It may, therefore, continue as at present. What is important is that instead of sporadic discussions on the issues that come up, the Council may take steps to constitute ad hoc committee, groups and even appointment of eminent persons as mediators/facilitators so as to have sustained, serious discussions and negotiations to arrive at solutions.

The following functions would be appropriate for the NWRC :

- To lay down the national water policy and to review it from time to time.

- To devise modalities for resolving inter- state differences with regard to water plans and such other issues that come up before it.
- To advise on practices and procedures, administrative arrangements and regulations for the fair distribution and utilisation of water resources by different beneficiaries keeping in view optimum development and the maximum benefits to the people.
- To advise on any matter having inter- state or National implications.
- To make such other recommendations as would foster expeditious and environmentally sound and economical development of water resources in various regions.

The Chairmen of all River Basin Organisations, as and when formed, may be the Members of the Council. The Central Water Commission may be the Secretariat for the National Water Resources Council.

8.19 National Water Board

The Government of India constituted this Board in September, 1990 with the Secretary, Ministry of Water Resources, Government of India as its Chairman, Secretary of concerned Union Ministries and Chairman, Central Water Commission, Government of India and Chief Secretaries of States/Union Territories as members. The functions of the Board are as follows :

- To review the progress of the implementation of the National Water Policy and report to the Council.
- To recommend the setting up of appropriate organisations and institutions for the integrated development of water resources as envisaged under the National Water Policy.
- To assess the achievements of the different institutions/agencies working on the appropriate measures for further action.
- To make recommendations on the pattern of financing of the water development projects for speedy and systematic development of the water resources.
- To suggest guidelines for the development and training of personnel required for the water sector.
- To make suggestions for undertaking appropriate programmes in pursuance of the directives in the National Water Policy.
- To suggest investment priorities in the water sector for achieving the objective of the National Water Policy.
- To consider any matter/problem associated with the development and management of the Nation's water resources and as may be brought up before the Board. Make suitable recommendations to the Ministry of Water Resources/ National Water Resources Council.

The Board has held ten regular meetings and one special meeting so far. It has served as a useful forum for centre – state discussions at the senior officers' level and on a number of complex issues agreement could be reached at the level of officers. The Board functions as a " Committee of the whole" of the NWRC and could be called as such. The CWC may be the secretariat for this body also.

CHAPTER – 9

ECONOMIC AND FINANCIAL MANAGEMENT

9.1 General

In most cultures, including ours, water is taken as Nature's gift and, therefore, access to water is considered as a basic right of every person and as a social good. However, as the availability of water is not equitably distributed over space or time, while the requirements are universal and perennial, efforts have to be made to include space and time utility to the natural supply of water, by investing in storage and conveyance. Thus, water partakes the characteristics of an economic good with an opportunity cost attached to it.

Another economic consideration which comes to play an important part in integrated water planning is the result of the limited and finite quantity of water and its ever-expanding requirements. Imbalance in the availability and requirement of water compels certain regulation in its use. Such regulations are common in all societies, though the forms vary. The methods of regulating the use of water range from pricing of water to its physical allocation for particular use. A whole range of institutional forms are also deployed to tide over the scarcity. Among various instruments used for matching supply and demand, pricing of water is an important one, but is found in practice to be difficult and sensitive. The question of 'cost recovery' is important in this context. It is obvious that if the cost of development is not recouped, long term disadvantages in terms of dwindling supplies and inadequate availability will become manifest.

In this chapter, we present an analysis of the economic and financial aspects of the development of water resources which we suggest should be considered carefully and acted upon in order to ensure its integrated and sustainable use. We do not wish to be alarmist or critical, but objectively stated, the financial aspects of the water resources sector are a matter of very grave and urgent concern. There is a huge gap between promise and performance and between the funds needed (just for ongoing projects) and the funds available. Some projects started in the 1950s are still not completed. Out of the 292 major irrigation and multi-purpose projects taken up till the end of the Eighth Plan (113 of them were started during the eleven years of 1974 to 1985), only 130 projects were completed. The investment on total irrigation as a percentage of overall plan outlay has gone down from 22.5 percent to 6.7 percent (Table 9.1).

As a result of taking up a large number of projects without required funds and a number of other factors, as explained in the next Chapter, cost and time over-runs have become endemic and chronic. Costs have gone up several times and yet, millions of farmers are waiting for the promised succour. The financial returns from the projects have been negligible due to highly subsidised pricing of water, but substantial under- utilisation in relation to the promised potential has also contributed to it. The returns are not even adequate to cover the operation costs. Maintenance has been sadly neglected and the systems are deteriorating. Central and state governments took on full responsibility to do everything, but have not been able to fulfil even a small part thereof. Safe drinking water remains a dream not only in dry areas, but also in all urban areas. Sewerage and treatment of urban waste water are woefully inadequate. Local resources development and management could have mitigated the deficiencies to some extent, but were not given the priority that they deserved. Indeed, the application of financial resources has not been optimal, with a view to getting early results and there is little regard in the entire system for prudential financial norms and accountability. Despite repeated statements and warnings in the plan documents, writings of scholars and others and reports

Table-9.1

Planwise Expenditure on Irrigation in India(As Percentage of All Sectors)

S. No.	Period	Major/ Medium Irrigation as Percentage of all Sectors	Total Irrigation as Percentage of all Sectors
1	First Plan (1951-56)	19.20	22.54
2	Second Plan (1956-61)	8.13	11.59
3	Third Plan (1961-66)	6.72	11.86
4	Annual Plans (1966-69)	6.49	14.88
5	Fourth Plan (1969-74)	7.87	15.27
6	Fifth Plan (1974-78)	8.78	14.27
7	Annual Plans (1978-80)	9.06	14.25
8	Sixth Plan (1980-85)	6.74	10.55
9	Seventh Plan (1985-90)	5.08	8.57
10	Annual Plans (1990-92)	4.00	7.39
11	Eighth Plan (1992-97)	4.18	6.69

Source: CWC – Report of the Working Group on Major and Medium Irrigation Programme for the 9th Five Year Plan

of committees and external financing agencies, the situation has not only not improved, but has deteriorated over the years. Unless urgent and drastic steps are taken to reverse the trend, the economy, as a whole will have to pay a dear price in the coming years. We have approached the whole question on the basis of this assessment.

9.2 Past Investment and Future Needs

Major and Medium Projects

Large amounts have been spent during the planning era on Irrigation Schemes. It is estimated that at 1996-97 price level, about Rs.1,32,390 crores were spent on major and medium projects upto that year. The figure works out to over Rs.2,31,387 crores, if expenditure on flood control, minor projects and command area development is also added. The ongoing projects are mostly large and medium projects. It has been estimated that the spill-over cost of the 162 major projects, alongwith medium and ERM projects at 1996-97 prices, would come to about Rs.1,36,133 crores at the beginning of the Ninth Plan (Chapter 10). The outlay for the plan period, as finalised by the Government of India, is Rs.42,974 crores. Taking into account price escalation during the plan period, the spill-over cost at the end of the Ninth Plan, would be around the same or even more than that at the beginning of the plan. It has been estimated very roughly that an amount of Rs. 70,000 crores in Tenth Plan and Rs. 1,10,000 crores in the Eleventh Plan would be necessary to complete all these projects.

These figures indicate the order of finances that are necessary and are not even reasonably accurate. This is because, even though the number of major projects is not large, precise information on commencement, year of revision of estimates and expected completion is not available. The revised estimates prepared in different years for different projects are added up to arrive at the amount necessary. Efforts to arrive at a common base year – at the beginning of the plan period – for revised estimates of all ongoing projects have not been successful and assumptions have had to be made on escalation and other factors to arrive at some estimate for a base year. Also, it does not seem to be clear when a project should be considered as 'completed'. Projects seem to have an extended life span and have become almost open ended. In earlier years, Completion Reports used to be prepared for each project. The reports were valuable guides to engineers regarding the types of technical problems that were faced and the solutions found, as well as on project management and financial accountability. There are hardly any Completion Reports since the last 30 years, despite specific requirements in financial and public works codes. The situation regarding major projects is disturbing as illustrated by the following :

The Working Group for the Eighth Plan estimated in 1989-90 that 109 out of 176 ongoing major schemes would be completed during that plan period. The entire spill-over cost, as assessed at the beginning of the plan, was recommended to be provided for the projects to be completed. The Eighth Plan was shifted by two years and it was estimated in 1992 that 80 projects would be completed by the end of Eighth Plan (1997). In November, 1994, the Planning Commission said that only 57 projects would be completed. The Working Group on Ninth Plan, based on available data, anticipated (in 1995) the completion of 38 projects. The present assessment is that 10 projects were most probably completed in the Eighth Plan.

As a result, increasing spillover cost has become a regular phenomenon. We have analysed a few schemes started in First and Second Five Year Plans. The status of these schemes at the beginning of the Sixth Plan (3/80) was as shown in Table 9.2.

Table-9.2

Status of Selected 1st Plan and 2nd Plan Schemes at the Beginning of 6th Plan

(Rs. crores)

Name of Scheme	Est. Cost	Exp. Upto 3/80	Spillover cost	6th Plan	
				Outlay	Exp.
Tungabhadra Dam & LBC	65.13	60.19	4.94	4.93	9.08
Bhander Canal	3.26	1.65	1.61	0.61	0.70
Barrage Irrigation System of DVC	30.15	24.65	5.50	5.50	5.50
Nagarjunasagar	533.00	360.00	173.00	173.00	36.22
Tungabhadra HLC	11.34	10.64	0.70	0.74	0.81
Kabini (NP)	78.94	60.62	18.32	-	32.80
Barna	15.27	14.91	0.36	0.36	1.17
Khadakwasla	100.00	43.08	56.92	15.00	43.78
Kangsabati	85.00	66.97	18.03	10.00	20.92

Source: CWC

The status of these old schemes at the beginning of the Ninth Plan (3/97) is given in Table 9.3.

Table-9.3

Status of Selected 1st and 2nd Plan Schemes at the Beginning of 9th Plan

(Rs. crores)

Name of Scheme	Est. Cost	Exp. Upto 3/97	Spillover cost	9th Plan Outlay
Tungabhadra	230.33	190.65	39.68	27.00
Bhander Canal	9.49	6.71	2.78	2.78
Barrage Irrigation System of DVC	60.00	56.68	3.32	4.03
Nagarjunasagar	950.00	851.35	98.65	115.00
Tungabhadra HLC	62.93	44.08	18.85	10.00
Kabini (NP)	1,307.00	292.83	1,014.17	-
Barna	31.25	27.63	3.62	3.62
Khadakwasla	345.06	225.88	119.18	75.13
Kangsabati	224.09	205.41	18.68	20.00

Source: CWC

When the two Tables are compared, it would be seen that costs have increased in a big way in almost all cases, that inspite of allocating full residual cost as outlay in a plan period, the spill-over costs are increasing and that the schemes do not even seem to be reaching completion.

Despite the fact that the financial figures are, at the most, best estimates, and at the least, guess-estimates, it is clear that it has not been found possible to provide government funds, in the plan, to adequately finance even ongoing projects. There will be no scope, therefore, for new major projects in the next two plan periods if the present order of financing continues or unless some of the projects are abandoned/ suspended under the scheme of prioritisation. This is a measure of the problem of funds faced by the major projects.

Some ameliorative measures have been taken up since 1996 to try to complete projects in advanced stages of construction by making additional funds available to them. The Accelerated Irrigation Benefit Programme (AIBP) was launched by the Government of India in 1996-97 as a central loan scheme on matching basis. Selected major and medium projects were financed under the programme during the last three years. The loan released, the number of projects and the additional potential estimated to have been created are given in Table 9.4.

Table-9.4

Progress of AIBP

Year	Number of		Loan Released (Rs. Crores)	Addl. Irrigation Potential created (Th. ha)
	States	Projects		
1996-97	18	52	500	70.6
1997-98	18	73	952	137.7
1998-99	14	77	1,119	338.1

Source : CWC

The budget provision for 1999-2000 is Rs. 1,600 crores and two major modifications have been made. One is that the central loan assistance should not be used to meet establishment costs and the other is that assistance would be given in the ratio of 2:1 (Centre:State) in the case of major states and 3:1 in the case of special category states and the KBK districts of Orissa. The changes made this year are in the right direction, as it appeared that sizeable portion of the funds was being spent on establishment. While this terminal project financing method has helped a few languishing projects towards completion, it makes only a modest addition in terms of the funds that are required by these projects. Also, there is a tendency to propose more and more projects for assistance, resulting in spreading even AIBP funds thinly over a number of projects. The procedures for release of funds require change and it is necessary to assess minimum number of years needed to complete the project/phase and provide funds for that period in a non-lapsable manner. We consider it essential that a detailed review and performance evaluation of the on-going old projects is done, during the Ninth Plan, so that appropriate lessons may be drawn and remedial measures taken in each case, at least in the Tenth Plan.

Minor Irrigation

Minor Irrigation has been given increasing importance in the Five Year Plans. At 1996-97 prices, over Rs. 73,389 crores were spent – Rs. 39,493 crores by government funds and Rs. 33,896 crores through institutional finance – on minor irrigation schemes from the beginning of the plan period. In addition, during the last ten years, under the rural employment programmes (NREP, RLEGP, JRY), minor irrigation and related works were taken up. There is considerable variation from state to state and from year to year, but on an average about 17.86 percent of the funds are being spent on such schemes. According to figures available with the Planning Commission, during the six years 1988-89 to 1993-94, Rs. 2,782 crores were spent on irrigation works under these schemes. It can be estimated that currently about Rs. 800 crores are being spent annually.

Efforts to step up institutional funding for these works have also been made in recent years. The Rural Infrastructure Development Fund (RIDF) was created by NABARD in 1995-96, with an initial corpus of Rs. 2,000 crores to extend loans to state governments for financing rural infrastructure projects including minor irrigation, soil conservation and watershed management. In the RIDF –I (closure by1997-98), Rs. 1,749 crores were sanctioned to 20 states for 3,517 minor irrigation and flood control schemes. Out of RIDF – II (closure by 1998-99), Rs. 2,618 crores were sanctioned to 14 states for 3,384 irrigation schemes. Under RIDF- III (closure by 1999-2000), Rs. 2,321 crores have been sanctioned for a total of 13,561 schemes.

Funds do not seem to be a problem so far as minor irrigation works are concerned. Questions have been raised about the longevity of the schemes and their viability. There is also the doubt that the same schemes are being done over again, once in a few years. It is a fact, however, that substantial areas have been brought under irrigation, especially in rain fed areas. Detailed micro-level research studies are needed to evaluate the results. Since substantial institutional funding is involved, NABARD should take the initiative to finance such independent studies.

Integrated Watershed Programmes

These are gaining greater acceptance from the point of view of lower costs, people's involvement, early returns and local soil, water and vegetative restoration and conservation. The efforts made in this direction are covered in detail in Chapter 6. A Committee of the Planning Commission has estimated the reasonable requirements of the next 25 years for such programmes as follows : 'The Government should aim at covering about 10 Mha of area for watershed development in the Ninth Plan on demonstration basis and thereafter, people should take lead in this matter. If need arises, ten percent of the project cost towards infrastructural and technological support may be subsequently provided by the government for enabling the people to obtain the best results. Assuming Rs.3,000 per hectare as the initial average cost, the physical and financial targets for perspective plan for watershed development are given in the Table 9.5. Thus, the entire treatable area could be covered by the end of Thirteenth Plan, with both government's and people's initiative. This would be not only realistic, but also cost effective and result oriented, as the people themselves will largely plan and implement the programmes.

Table-9.5

Physical and Financial Targets of Perspective Plan for Watershed Development

Plan period	Area to be covered by (Mha)		Cost per ha	Total cost at 1994-95 prices		
	Govt.	People's Initiative	(Rs.)	Govt. (Rs. In crores)	People (Rs. in crores)	Total (Rs. in crores)
9th Plan	10	5	3000	3000	1500	4500
10th Plan	7	8	3000	2100	2400	4500
11th Plan	5	10	2800	1400	2800	4200
12th Plan	3	12	2600	780	3120	3900
13th Plan	2	13	2500	500	3250	3750
Total	27	48		7780	13070	20850

Source: Report of the Committee on Twenty Five Year's Perspective Plan for the Development of Rainfed Areas

The order of funds estimated for integrated watershed development could be found from the integration of all area programmes as stated later in this chapter. The main problems are attitudinal and organisational and not financial.

Ground Water

As stated in chapter 4, there has been spectacular development of ground water during the last four decades, with nearly half the irrigated area now being dependant on this source. A very large part of the investment on dug wells, bore wells, tube wells and lift schemes as well as on the pumps – electrical and diesel, has been made by the private sector. No reliable estimate of this is available, but that it is substantial, is evident from the area irrigated. Public investment on this has been generally included under 'minor irrigation'.

Domestic Water Supply & Sewerage

In case of water supply and sewerage, the gap between needs and the available government funds is as wide as in the major irrigation sector (Chapter 5).

O & M Requirement

Construction of water projects is not an end in itself. The task of operation and maintenance of the created system is more important for realising full benefits envisaged at the time of their approval. This aspect has been examined by several bodies which have shown that the operation and maintenance of irrigation and drainage systems are badly neglected. The Committee of Ministers on "Under Utilisation of Created Irrigation Potential" (1973) observed that O&M of irrigation and drainage systems is often a neglected field and is an important factor for under utilisation of created potential. They felt that the grants given for operation and maintenance of irrigation projects are inadequate and the system cannot be operated with reasonable efficiency and the entire irrigation programme suffers. The Groups constituted to formulate programmes of major and medium irrigation schemes for various Five Year Plans have examined the subject of working expenses on major and medium irrigation systems. They observed the following deficiencies in the prevailing practices :

- While existing expenditure norms for maintenance of major and medium irrigation systems are on the low side, provision is not being made even at the present rate by several states. Increase in norms itself will not, therefore, ensure proper maintenance. Means are to be found for providing the required funds.

- The present system of fixing flat rates per hectare of irrigated area for operation and maintenance without taking into consideration the nature and type of projects is not rational, for example, the present system does not distinguish between a diversion or storage work. Even in storage works, requirements of maintenance of earthen/rockfill dam and concrete or masonry dam cannot be same. In case of dams, regular surveillance and follow up action for safety of dams is also necessary.

- The maintenance charges of irrigation systems below the head works cannot be uniform throughout the country as this will vary from place to place depending on the peculiarities of topographical and meteorological conditions. The norms should be suggested by each state after detailed studies in different regions. Since the funds for operation and maintenance are part of non-plan expenditure, sufficient provision is not made due to restrictions on non-plan expenditure. The major part of the allotted money is being spent on staff payments. As a result, essential repair and maintenance works are not carried out and the system deteriorates. Many of the schemes coming under the garb of modernisation for taking up under the Plan are actually meant to attend to these accumulated repair and replacement backlog.

The Groups emphasized the necessity of proper upkeep and maintenance of existing irrigation systems to remedy the paradoxical situation, namely, while the nation spends Rs. 25,000 to 35,000 (at 1988-89 prices) to bring one additional hectare under irrigation, it is loosing existing available irrigation coverage gradually by not spending Rs. 200-250 per hectare annually for maintenance.

These observations remain valid even today and the situation has, in fact, worsened. Urgent steps are, therefore, needed to prevent more damage. The challenge of O&M is more urgent than even the challenge of ongoing projects.

9.3 Augmentation of Government Funds

In view of paucity of government funds, efforts are being made to augment funds either by i) finding other sources or ii) by arranging for specific components of projects to be financed by beneficiaries. The Ministry of Water Resources, at one time, proposed i) earmarked funding of National Projects and ii) setting up of an Irrigation Finance Commission. Both these did not materlise for obvious reasons. In a sensitive subject like financing of major irrigation projects, the selection of National Projects is a ticklish question. If the responsibility for financing is taken upon by the Centre, there is likely to be a race for inclusion as National Projects, defeating the very purpose behind the idea. As proposed elsewhere in this report, prioritisation and projectwise financing are more rational and better alternatives. Since returns in this sector are very low, an Irrigation Finance Commission would not be viable and could at best be a channel for routing mostly government funds. A Commission could be considered at an appropriate time, after the initial steps for improving the returns as proposed in this report are taken.

One of the Groups on major and medium projects for the Ninth Plan, went into the whole question of funds. It made several suggestions for augmenting resources, the more important of which related to :

1. Funding by NABARD
2. Water equity or Bonds
3. Private Sector Participation
4. Commercial exploitation of land (adjacent to major canal reservoirs)
5. Integration of rural development & water resources sector
6. Farmer's participation

Funding by NABARD

It has been suggested that the RIDF scheme may be expanded and also extended to subsequent years of the Ninth Five Year Plan. Further, there are certain ongoing major water resources schemes, which are likely to be completed within next few years creating substantial irrigation potential. As such, a change in policy relating to financing by NABARD under RIDF was also suggested to include such beneficial schemes, as sub-projects of major schemes. It is seen that a portion of RIDF is already being spent on major irrigation schemes. However, being a banking institution, NABARD recovers the loan amount alongwith interest and this liability will have to be met by State Governments, adding to their debt burden and fiscal deficit. There are, therefore, obvious limits, as at present, to the volume of funds that NABARD can commit to the irrigation sector, in which the direct financial returns are negligible.

Water Equity or Bonds

It is proposed that farmers and other user groups should be made co-owners of the irrigation works through equity shares. The suggestion is that a percentage of capital invested in the project could be offered as equity shares to individual farmers and other users, as well as to other associations. This could also be done in exchange for labour contribution to project construction. The 'equity share' issued to the farmers would be thought of as financing instruments as well as entitlement to the water. Water entitlement will be made proportional to the land area of farmers in the command. It is expected that at least the cost of construction and maintenance of distribution canals could be covered by such arrangements, even though major investment would have to be by Governments. This route should be pursued to the extent possible.

In a similar manner, it has been suggested that water or 'Sinchai' bonds may be issued for projects. Karnataka adopted a scheme for raising resources for completion of ongoing major water works from the market. Krishnabhagya Bonds issued by Krishna Bhagya Jal Nigam (A Govt.of Karnataka undertaking) is one such scheme that offers secured redeemable non-convertible bonds at 17.5 percent interest. On the same pattern, Maharashtra established the Maharashtra Krishna Valley Development Corporation for raising resources through issue of bonds. The economic logic of offering such high rates of interest, when returns are negligible, is not clear. The depositors in the bonds and the beneficiaries will not be the same and therefore, full recovery of water user charges by adjustment of interest/capital is not practicable. The irrigation bonds would have adverse effects on the public exchequer, since interest and repayment will have to be met out of public funds and can, therefore, be resorted to only in a few cases. Bonds would have greater relevance in the case of water for industrial use and urban water supply and should be used to the maximum extent possible in such projects.

Private Sector Participation

This is being considered increasingly in all sectors, in the context of paucity of funds. In order to examine the feasibility of private sector participation in irrigation and multipurpose projects, a High Level Committee was constituted in the Ministry of Water Resources, under the Chairmanship of Union Minister of State for Water Resources in the year 1995. The Committee recommended introducing the concept on a pilot basis in respect of certain projects which did not have interstate problems (or security issues). It was felt that the concept could be extended to more and more projects on gaining experience and that initially such investment could be thought of particularly in the case of ongoing projects which were in advance stage of construction but were incomplete due to lack of funds. The Committee also recommended competitive bidding to ensure transparency and cost effectiveness. Other recommendations were:

- Cost recovery methods, water rates allowed and guarantees, if any, should be specified.
- Considerable improvement in the procedure of clearance of projects is called for and the procedures should be simplified as much as possible to promote private sector participation.
- Obligation of the government and the private sector should be clearly spelt out in the agreement. Provision should also be made for settlement of disputes and arbitration.
- Some incentives have to be offered to the private sector including avenues to augment revenues. These could be in the form of tax holidays, floating tax free revenue bonds, loans at concessional rates including moratorium on repayment etc.
- Forming of a definite policy and its adoption by the National Water Resources Council may be essential for implementing this concept. A well prepared publicity campaign will be required for wider participation and its eventual success.
- Various combinations of building, owning (of structures etc.), operating, leasing and transferring may have to be considered. The exact type may be decided by the States as considered appropriate by them. The main objective should be towards finding ways and means that are more efficient, responsible and environment-friendly for development and optimum utilisation of country's available water resources.

We would, however, like to point out that private sector participation would be forthcoming only if private sector is confident of getting adequate returns from users of water. Private sector is engaged in a major way in the exploitation of ground water, but not in the financing of irrigation projects. Private sector participation would of course be practicable in projects mainly intended for supply for industrial use and urban water supply and for these components in other major projects. Some initiatives in respect of private sector participation have been taken in the States of A.P., Karnataka, M.P., Maharashtra & Orissa, especially for water supply systems. The experience of operationalisation of such initiatives and the results thereof have to be evaluated and appropriate lessons drawn from it.

Commercial Exploitation of Land

Water resource projects lead to indirect advantages which can be exploited for generating revenue. For example, areas around reservoirs and the embankments of water resource projects could be developed for recreational facilities/tourist resorts by the private sector on mutually agreed conditions. The returns have to be attractive enough to ensure that the canals are not polluted and the reservoirs and embankments are well protected and maintained. It may not be an important means of generating revenue for development of water resources, but can have a role in specific locations and should be exploited to the extent possible.

Integrating Rural Areas Programme with Water Resources Sector

We have suggested the integration of rural areas programmes and a part of rural employment programmes of the integrated rural development in Chapter 6 on 'Local Water Resources Development and Management'. This can be the principal source of funds for integrated watershed development and minor irrigation and will be a more effective way of using funds for rural areas leading to economy and efficiency. The order of funds that would be available by such integration, as well as from AIBP, RIDF, other institutional finance and bonds during the Ninth Plan Period for the irrigation sector as a whole, may be around Rs. 90,000 crores. Alongwith peoples' contribution, this would be adequate for the purpose in view.

Water Users' and Community Participation

The need for encouraging strong and effective farmers' organisations/Water Users Associations (WUA) has been stressed by us in Chapter 8. The maintenance of minors (500 ha) could be handed over to the WUAs. This would bring about a reasonable reduction in the costs and responsibility of the government agencies. Besides routine operation and maintenance, the farmers' organisations/WUAs could also take up the task of collecting revenue from individual beneficiaries so as to improve upon the revenue collection. The success story of the Water Users Associations already operating in some of the States needs to be extended to other areas, with suitable local adaptation.

For field level works in the case of major projects, minor irrigation works, repairs of tanks and other works in rural areas, as much funds as possible should be generated through community involvement. There is considerable scope for this and it will relieve pressure on Government funds.

External Assistance

External financial assistance is another possible source to augment funds. During the Eighth Plan, the externally assisted irrigation projects accounted for 18 percent of the total estimate of ongoing projects. The foreign assistance forms only a part of the cost of the projects and because of strict conditions relating to procedures, cost estimates, environment and rehabilitation issues, the overall amounts available and the number of projects to be assisted in the future will continue to be limited. The bilateral donor or agencies have been interested in and continue to assist water supply schemes and integrated watershed projects. International and bilateral assistance for both these latter type of projects could be substantially more, if utilisation of funds is improved by making major procedural changes in the disbursal of funds and if projects are completed on time. Failure on both these fronts has had a dampening effect on external assistance.

In general, all the above means for augmenting the financial resources, have to be encouraged to the maximum extent possible. To the extent they are successful, many neglected activities can be better looked after and there will be lessening of pressure on government funds. For main works of the major projects, however, government funds would continue to be the principal source and they have to be better applied and managed (chapter 10).

9.4 Suggested Measures for Greater Financial Discipline

The weakest point in the sector is the lack of financial discipline all round. Augmented funds would not solve problems, unless stricter project management and efficient application of funds are achieved. We suggest the following measures for immediate adoption so as to instill a measure of financial discipline in the system :

Major Projects

- As was the case in the early years of the plan period, assistance to large projects may be project wise from 2000 AD, instead of being part of the overall plan assistance. The assistance for large projects may be deducted from the Central assistance to a State and kept as a separate pool/fund. Within a large project, funding could be earmarked for phases and sub-systems also.

- The projectwise allocation may be on the basis of the prioritisation as suggested by us (Chapter 10).

- A pre-requisite for project funding and efficient project management is the availability of up-to-date revised estimates. These may be got done in the next two years (1999-2001) for all the ongoing projects. A Monitoring Committee may be constituted for this purpose. Thereafter, the estimates so revised may be got revised every year of the plan period.

- In the case of new projects, the project cost should cover escalation over the proposed construction period and the project should indicate both the basic cost and the estimated completion cost. The cash flow assumed in the Project Report should be got certified by the State Finance and Planning Departments, to indicate the state government's commitment.

- In the absence of clear understanding as to when a project should be considered as having commenced and completed, it is necessary to lay down the criteria regarding these for all to adopt:

  A project should be considered as having commenced, only after the issue of formal administrative approval and technical approval by the government which should be given only after techno-economic viability is established by the designated authority. All expenditure incurred prior to this should be shown against investigation and preparation.

  Major projects should be broken into identifiable and meaningful phases/sub-systems /components. 'Completion' should be considered for each such phase/component. The irrigation component should be considered to have been completed, if 90 percent of the physical progress is achieved and the status continues for one year and if at least 80 percent of the estimated potential is created. The balance should be dealt with as a separate scheme.

- A Completion Report should be prepared for each project/phase. To ensure this, an amount of rupees one to two crores may be retained in the final bill for reimbursement under project financing. The amount may be released only if the Completion Report is itself completed.

- Since establishment costs are soaring and in the extended period of projects rise to unconscionable levels, a ceiling on establishment costs (including work-charged) should be enforced. The ceiling should be 20 percent of the cost and every effort should be made to keep it around 12 to 15 percent. Expenditure above 20 percent should not be reimbursed.

- The scope of a project should not be allowed to change, except after prior mid-project appraisal and specific approval. If there is change of storage/capacity of main canal/potential, over 10 percent of what was envisaged at the time of approval of the project, a project should be considered to have changed in 'scope'.

Medium Projects

- The CWC should concentrate on large projects and monitor them more closely. The approval and implementation of medium projects may be left to the states. One objection is that many of these are on tributaries of inter-state rivers and questions of design of excess capacity would arise in that context. It may be laid down that in all such cases, the state proposing the project shall notify it in the Gazette and to the concerned states with full details of the parameters laid down by the CWC. If there are objections, within the prescribed period, they should be sorted out mutually or through the Basin Organisations that we have proposed in this Report for each major basin. Until such organisations are created, if there is no mutual agreement, any of the parties could take up the question with the CWC for decision.

- The principles regarding commencement, completion and establishment costs suggested for major projects shall apply to these projects also and it is for the state authorities and audit to ensure them.

9.5 Pricing of Water

As stated earlier, water is both an economic and social good. Water used for irrigation is an economic good and its logical pricing is a key to improving water allocation and encouraging conservation.

During the pre-independence period, irrigation projects were constructed and operated as financially viable ventures, except for those specifically considered as protective works. After independence, they were viewed as instruments of development and social benefits. We deal with the criteria for economic and financial analysis of projects in the next chapter in some detail: Here we would only like to note that,in practice, the financial returns are negative in all the projects.

The present canal water rates in the states are still area based depending on crops and seasons and sometimes the reliability of supplies. There is very wide variation in the rates even for the same crop. The charges are also very low and have not been revised for many decades in most states. Table 9.6 illustrates this strikingly.

Table-9.6
Water Rates for Principal Crops in various States and Year of Revision

Sl.No.	States	Water Rates (Rs./ha)			Year in which rates were last revised	Remarks
		Rice (Kharif)	Wheat (Rabi)	Sugarcane		
1	Andhra Pradesh	494	494	494	April, 1997	w.e.f. 1.7.1996
2	Arunachal Pradesh					No water rates levied.
3	Assam	140.62	281.25	111	March, 1993	
4	Bihar	175.00	150	370	Nov.,1995	
5	Goa	150.00	NA	300	1.2.1988	
6	Gujarat	125.00	110	830	1981	
7	Haryana	113.15	91.39	148.20	1998	
8	Himachal Pradesh	24.3	14.6	41.09	1977	
9	J&K-Jammu-	20.1	10.8	20.07	1976	
	Srinagar	16.3	8.2	NA	1976	
10	Karnataka	86.5	54.4	370.67	1985	
11	Kerala	99.0	62.0	99.00	1974	
12	Madhya Pradesh	197.69	247.11	741.33	1992	
13	Meghalaya					No water rates levied.
14	Maharashtra	200.00	200.00	1750.00	1.7.1994	
		200.00	200.00	2625.00	1.7.1998	
		220.00	220.00	2890.00	1.7.1999	Declared the
		240.00	240.00	3175.00	1.7.2000	rates in
		265.00	265.00	3495.00	1.7.2001	Advance.
		295.00	295.00	3845.00	1.7.2002	
		320.00	320.00	4230.00	1.7.2003	
15	Manipur	75*	37.50	NA	Dec., 1981	
16	Mizoram					No water rates levied.
17	Nagaland					No water rates levied.
18	Orissa	100.00 @	85.00	250	1998	
19	Punjab	-	-			Water free of charge.
20	Rajasthan					
	-Pre-1952 Works	56.8	51.9	123.56	1982	
	-Post- 1952 Works	98.8	74.1	143.32	1982	
21	Sikkim					No water rates levied.
22	Tamil Nadu	37.1	NA	49.42	1962	
23	Tripura	30.0	30.0	NA		At present no water rates are being collected.
24	Uttar Pradesh	287.0	287.0	474.00	1995	
25	West Bengal	37.1	49.4	370.66	1977 & 1984 for minor irrigation	
26	A&N Islands					No water rates levied.
27	Chandigarh					Data not available.
28	D&N Haveli				1970,71,72 and 73	For different schemes.
29	Daman & Diu				1980	
30	Delhi				During IVth Plan	
31	Lakshdweep					No water rates levied.
32	Pondicherry				1979	

Source : Planning Commission

* *Early Paddy Rs. 75.00/ha. Kharif Rs. 37.50/ha*

@ *Compulsory Kharif I class Irrigation work Rs. 225/ha for Dalua.*

There is no similarity in the practices followed by various States. There are some States which provide water (and often the related power) free of cost to some categories of farmers. In some others, irrigation charges are combined with land revenue. In some, they vary only by seasons while in a few others, they depend on land classification, like wet and dry lands. In some States there are different rates for water supplied by perennial and non-perennial canals. Some States differentiate between various classes of projects for charging water rates. There are many other variations depending on categories of services provided.

It is seen from the figures of gross annual receipts and working expenses of major and medium projects for the period 1974-75 to 1986-87 for purely irrigation projects that the gross recoveries went down from about 85 percent of working expenses in 1974-75 to about 42 percent in 1986-87. This was mainly due to large rise in working expenses while the water rates remained more or less stagnant. For surface minor irrigation schemes also, the percentage went down from almost ten percent in 1975-76 to about two percent in 1986-87.

The revenue receipts have been very low due to reasons like :

- Very low water tariffs and reluctance of State Governments to review and increase the rates periodically to keep pace with rising capital and O&M costs. Many States have not revised the rates since early 80's and some are continuing the rates fixed in early sixties and seventies.

- Physical and operational inadequacies of the created facilities resulting in low and uncertain utility and consequent low collection of water charges.

- Present method of charging for water on area crop basis instead of volumetric basis resulting in substantial wastage. Lack of incentives to farmers for saving water which can be utilised to serve larger areas.

- High level of working expenses, especially on establishment.

- Inefficiency in revenue collection organisations and inadequacy of the collection system giving rise to large arrears.

There are a number of ways in which the returns can be increased. The returns can be increased expanding the benefited area by saving water. The working expenses can be reduced by modernising the system, better water management, organisational reforms and improved infrastructure (chapter 4). There is great scope for reducing O&M costs by curtailing overstaffing by redeployment, providing better communication facilities and establishing participatory management. Water rates are so low that they need to be increased substantially, but one of the important ways to overcome resistance would be to increase reliability and efficiency through these means. Increase in water tariff could be resorted to only alongwith restructuring measures.

As for the rates themselves, there are three basic approaches to setting charges. Rates can be related to the cost of providing irrigation or to the benefits to be derived from irrigation or to some value judgement on the beneficiaries'ability to pay the rates. Marginal cost pricing, though theoretically favoured has several practical limitations in practice. Various Committees and Commissions examined the issue from time to time and have given their recommendations. The Irrigation Commission, 1972 recommended that the water rates should be five percent to twelve percent of the total value of farm produce, the lower percentage being applicable to fodder and food crops and the higher for cash crops.

Several Finance Commissions have been recommending rates linking them to annual O&M costs and some percentage of capital cost. In the recent past, the Vaidyanathan Committee in 1992 went into the whole question comprehensively and recommended a two-part tariff, in the first phase, comprising a fixed charge of Rs.50/- applicable to entire command area as a membership charge and a variable charge per ha of irrigation to recover annual O&M cost and one percent interest on capital cost. The objective is to move towards full-cost recovery. The change was to be brought about in three phases, ultimately leading to rates on volumetric basis with improvement of existing systems, creation of autonomous, financially self-reliant entities at the system level with participatory management by users. The Committee also suggested that while fully volumetric charges would take time to implement, a beginning could be made by shifting from the present crop-specific, area-based rates to rates related to area irrigated in each season (irrespective of the crop grown) so that differences in irrigation requirements between seasons were captioned.

The Group of Officers appointed by the Government of India to examine Vaidyanathan Committee's report generally endorsed the recommendations, but did not favour the fixed charge part as most the state governments did not agree to such a two part tariff. The Government of India forwarded the recommendations to various State governments for considering their implementation. Unfortunately, the response from the State Governments. has not been encouraging. None of the state governments has revised the water rates accordingly.

For domestic and industrial uses, Vaidyanathan Committee recommended that the costs of supply of water should be fully recovered through appropriate volumetric rates and arrangements should be built into the supply contracts for ensuring full and prompt recovery of dues.

The logic followed for the recommendations about water rates made by various Committees and Commissions is as follows :

- The irrigation systems in the country should move systematically towards supplying irrigation water volumetrically in the ultimate stage. This will not only help conservation of water but will also improve assessment and collection of the water dues.

- As the physical and operational structures of many existing irrigation systems are not suitable for immediate introduction of volumetric system of tariffs, the change will have to be brought about gradually and in well defined phases.

- As an intermediate stage, it is possible to introduce volumetric supply of water at the minor/water course head for groups of farmers in a continuous area. Minimum pre-requisites for this will be the provision of control structures including cross regulators and measuring devices to ensure accurate measurements of flow and formation of Water Users' Associations (WUAs) below the areas covered at the minor head or the watercourse head.

- Users have to be induced to acquire significant direct stake in the system by contributing a part of the cost of improvement and by moving towards allocation and pricing based on contracts between the system's management and the users' associations. A two part tariff at the initial stage, will help to establish a contractual entitlement and a greater sense of interest among the users.

- Until such structural changes and operational procedures are finalised and implemented, the present method of area based tariff will have to be continued though (i) it is complicated due to differentiation in rate structure resulting from varying agro-climatic conditions; (ii) it is not related to supply cost or scarcity value of water; and (iii) it does not provide any incentive to farmers for economical use of water.

With the background of the past proposals, especially those detailed ones made by the Vaidyanathan Committee, the following general principles are recommended by us :

- There should be rationalisation of basic principles of fixing the water tariffs in all the States.

- The irrigation Commission (1972) had recommended rate structure linked with value of gross product of irrigated hectare irrespective of the working expenses. Vaidyanathan Committee had tied up the rates with O&M cost and a part of the capital cost without reference to value of the product. It is felt that both these approaches should be combined so that the rates are adequate to cover annual O&M costs and also cover a part of the productivity gains of the farmers. As it is difficult to assess the precise productivity impact of irrigation alone on crop-by-crop basis, the tariff should be linked to the gross value of products and not to incremental benefits. The cash crops should pay higher rates as their farmers have greater capacity to pay.

- The water rates should accordingly cover the entire annual O&M cost plus one percent of the gross value of the produce/ha in respect of cereal crops and a higher percentage in case of cash crops.

- These rates should be levied as single part variable tariff for the present. However, the scheme of charging a basic fixed rate alongwith a variable part is quite logical and should be followed up with the State Governments.

- Some States have supplementary levies like betterment charges, Mandi-charges etc. The States may continue these additional charges.

- The revised water pricing structure should be such that the rates are substantially lower for those who accept group volumetric supply than for individual farmers. Also, the WUAs should be allowed to collect a little over and above the prescribed water rates to encourage them to improve the system under their charge.

- Though area, crop and season based tariffs are in force in various States at present, they require inter-se rationalisation to reflect varying degrees of water consumption by various crops and their economic values.

- Looking to the extremely low existing rates and the policy of subsidising water which has been continuing since several decades, it is not practicable to enhance the water rates in one single step. Subsidies in the rates in the form of lower percentage applicable to gross value of the products may have, therefore, to be continued for sometime and gradually phased out.

- Past O&M expenses have been found to be very low because of inadequate budget allocations. Realistic O&M costs/ha should be worked out by each State on pilot representative systems by allotting adequate funds. These figures should be used for fixing of rates. However, in working out the cost, the ceiling rates on establishment charges should be invariably followed.

- There should be two distinct components of irrigation water charges; one for O&M and other related to the value of the product. The O&M component should be fully utilised for the operation and maintenance of the respective portions of the system. The second part should be used to modernise the system with supplementation, from budget allocations. Each State will have to decide the natural proportion of the two components based on its figures of O&M and the productivity of the crops. The financial procedures should be modified to make this possible, so that the farmers are encouraged to pay the enhanced rates. At present, all the receipts flow into the common consolidated fund of the State and expenditures are provided for in the departmental budget commonly for all projects.

- The rate structure should differentiate between the seasons and also the crops in such a way that production or benefits are optimised per unit of water or at least indicate the intention. Thus the rates should be so rationalised that the water intensive crops are charged proportionately more as compared to less water consuming crops.

- On the basis of hydrological records, the existing surface irrigation projects should be classified into those with performance reliability of (a) 75 percent or above and (b) less than 75 percent. Considering a minimum reliability of 50 percent, the water rates for the latter should be two-thirds of the full rates fixed for the former. This is with the view indirectly to compensate the farmers under less reliable projects for loss of production during lean years. Even in respect of (a), there should be declared rates of rebate for non-supply of the assured quantum.

- The objective should be to achieve volumetric measurement ultimately, though gradually, and this should be kept in mind at every stage.

- The change should encourage user group formation and give adequate incentive to group consumers, who can be supplied water on volumetric basis, over individual consumers who have to be charged on crop area basis.

- The pricing for water of lift irrigation scheme should be worked out on the basis of the capital and O&M costs of these schemes. As this water will be easily measurable, the tariff should be fixed on volumetric basis. The schemes can be categorised according to lift ranges and rates be fixed for different categories. As the conveyance losses will be very low in case of lift schemes, the gross irrigation requirement will be much less. The capital costs would also be low. Even then, because of high operational costs, the rates/ha may work out to be somewhat higher than those for gravity flow irrigation.

- An important issue in fixing the basis for tariff for irrigation water is equity consideration. It is argued that increasing water charges will adversely affect small and marginal farmers. It is, therefore, proposed that farmers with large holdings, say, exceeding 10 ha may be levied a suitable surcharge. While the point is well taken, it may also be argued that small and marginal farmers' interest is taken care of by separate measures under which subsidised inputs and credit at concessional rates are provided to them. It is not feasible nor is there need to provide each and every input at subsidised rates, specially irrigation water which is the scarcest of all inputs. Moreover, there are only a very limited numbers of large farmers. Any surcharge will, therefore, not yield significant amounts.

- In the case of supplies for industrial purposes, the principle of 'user pays, polluter pays' has to be applied and water charges fixed accordingly, adding a premium for security, in water-scarce regions. In the case of domestic supply, a certain fixed quantity per connection may be free, in addition to the public taps, and charges increased progressively for larger use. The principle of seasonal water rates could also be tried.

9.6 Water Pricing Authorities

The above are broad guidelines and the details have to be worked out and operatinalised in each state, perhaps separately for regions in large states or even for projects. We believe that suggesting a uniform formula for the entire country would have no practical value. We, therefore, propose that a Water Pricing Authority be constituted in each state by statute, on the analogy of the energy pricing authorities and the general principles, with suitable local modifications, incorporated as guidelines for the Pricing Authority. The pricing structure suggested by the Authority, after hearing all the parties concerned, should be binding on all concerned. Any subsidy proposed to be given by the State Government for any particular use would be transparent and given as such as a subsidy for such time as the government decides. The subsidy should not affect the funds for the water sector. We belive that the constitution of independent pricing authorities would help bring about the long over-due changes in the pricing of water.

CHAPTER – 10

PROJECT PLANNING AND PRIORITISATION

10.1 Background

Project planning and implementation in irrigation sector have a long history in India. In the preplan period, 75 major projects with an irrigation potential of 9.304 Mha & 143 medium schemes with potential of 0.407 Mha, notable among them being Upper Ganga Canal, Krishna & Godavari Delta systems, Grand Anicut, had been completed. In addition to these, there were many minor surface and ground water development projects and the total pre-plan irrigation potential created was 22.6 Mha. The pace of project formulation and implementation got accelerated under the Five Year Plans after independence (Chapter-4).

Upto the end of the Eighth Five Year Plan, 292 major projects and 944 medium projects were taken up. Out of these, 130 major projects & 698 medium projects were completed. Plan-wise status of major and medium projects taken up and completed (cumulative) is given in Table 10.1.

Table – 10.1

Major & Medium Irrigation Sector Projects During Plan Periods

		Major Projects (Cumulative)		Medium Projects (Cumulative)	
Plan		**Taken up**	**Completed**	**Taken up**	**Completed**
I	(1951-56)	44	5	169	35
II	(1956-61)	77	25	271	131
III	(1961-66)	109	35	315	181
AP	(1966-69)	130	40	345	226
IV	(1969-74)	152	55	418	288
V	(1974-78)	222	61	718	354
AP	(1978-80)	235	63	770	371
VI	(1980-85)	265	95	861	519
VII	(1985-90)	277	111	894	655
AP	(1990-92)	288	130	894	668
VIII	(1992-97)	292	130	944	698

Source: CWC

Graphical presentations are annexed as Fig. 10.1 and 10.2 for major projects and medium projects respectively. The graphs show, how the number of projects under construction have increased at a rapid rate from the Fifth Plan. The increase in the number of ongoing projects with reduction in project funding led to thin spreading of resources and further delay in completion of projects. Since time over-runs lead to cost over-runs delaying the realisation of benefits, stress was laid from the Seventh Plan onwards on avoiding taking up of new projects. Although the number of new starts was reduced due to this policy, it could not lead to any significant reduction in the number of ongoing major projects. Also, in spite of spending large sums, more or less in accordance with the approved outlays, the number of projects completed was much less than planned.

Such a large carryover of incomplete projects implies locking up of capital and land for a long time without any returns and hence amounts to wasteful use of scarce resources. Costs escalate over time and the returns decline. Hence, it is important to prioritise projects and concentrate all the capacity and financial resources on a few projects at a time, in order of priority, for the sake of early completion and derival of benefits. Early accrual of benefits from some may in fact enhance the capability of the system to undertake more projects and at a faster pace.

We have attempted here to evolve a set of guidelines and rules for prioritisation of projects. "Prioritisation" cannot be a one time exercise since there is a continuing addition to the stock of possible projects. It may have to be done at the beginning of every five year plan. Guidelines have to be applied at the level of the state governments which is the most relevant level for making decision about the implementation of important projects.

Considering financial constraints, in addition to prioritisation of projects, it would become necessary to implement many of the ongoing major projects in phases, by dividing a major project into identifiable and meaningful sub-systems. Funding for identified sub-system would help in achieving the potential in a phased manner commensurate with the expenditure incurred.

TYPICAL PERPETUAL PROJECTS

(Rs. in Crores)

Sl. No.	Name of Project	Started in Plan	Original Cost	At beginning of 6th Plan		At beginning of 9th Plan	
				Cost	Exp.	Cost	Exp.
1	Tungabhadra dam and LBC	I	33	65	60	230	190
2	Nagarjuna - sagar	II	91	533	360	950	850
3	Khadakwasla	II	12	100	43	345	226
4	Kabini(Non Plan) (Unapproved)	II	-	79	61	1307	293

The cost have increased enormously; Residual Costs are also ever increasing. The projects do not seem to be nearing completion even by the end of the Ninth Plan. Unapproved schemes under non plan are continuing with very low outlays.

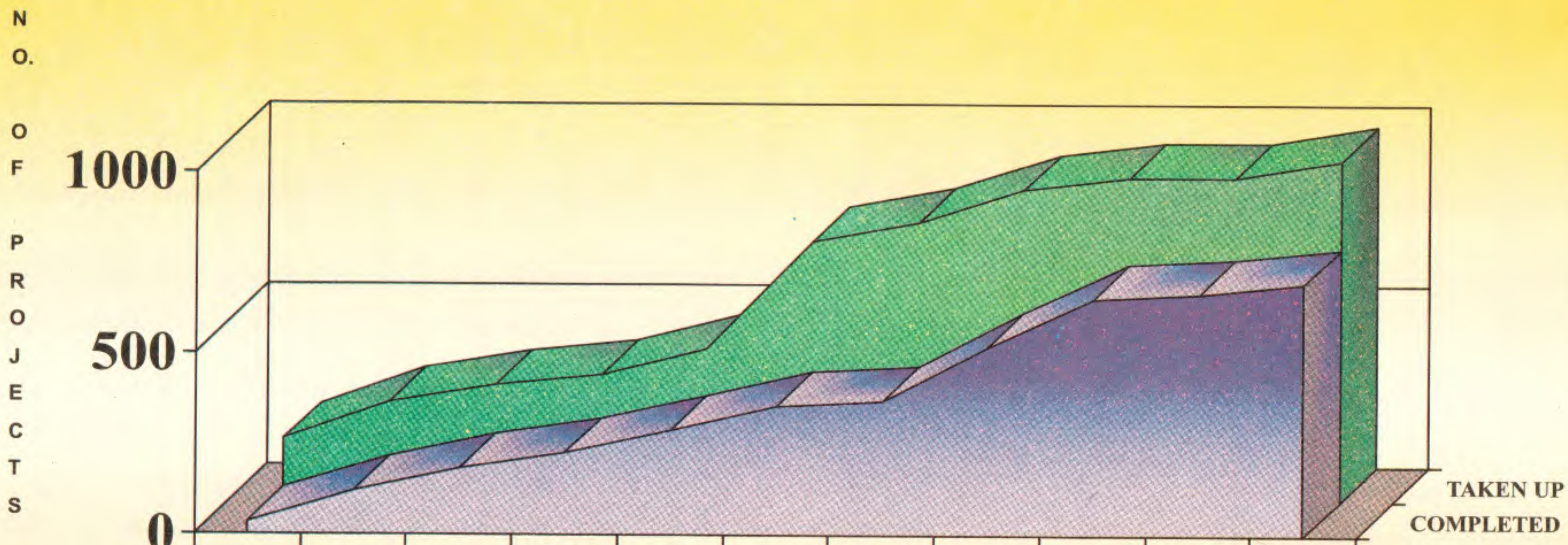
Fig. 10.1: MAJOR PROJECTS

TAKEN UP AND COMPLETED (CUMULATIVE)

	I	II	III	AP 66-69	IV	V	AP 78-80	VI	VII	AP 90-92	VIII
COMPLETED	5	25	35	40	55	61	63	95	111	120	130
TAKEN UP	44	77	109	120	152	222	235	265	277	288	292

Fig. 10.2 : MEDIUM PROJECTS

TAKEN UP AND COMPLETED (CUMULATIVE)



	I	II	III	AP 66-69	IV	V	AP 78-80	VI	VII	AP 90-92	VIII
COMPLETED	35	121	181	226	288	354	371	519	655	668	698
TAKEN UP	169	271	315	345	418	718	770	861	894	894	944

I. Project Planning

10.2 The Changed Context of Project Planning

Project planning in water resources sector in India started at a time when irrigation was the predominant, and often, the only use. It started in an era when energy for pumping surface and ground water was not available in the rural areas, and when land was comparatively plentiful and projects were less complex. Problems of waterlogging had not surfaced and the need of full utilisation of resources was not acutely felt. The situation has changed enormously over the years, and hence, there is need to make changes in approaches to project planning, particularly in respect of allocation of water among various uses, dependability and carryover related issues, conjunctive use, water lifts, project sizing and viability criteria.

Flexibility in Water Allocation

Even though domestic water supply (water for life) should have the highest priority in allocation of water among various uses , water sector projects still get planned as single use (irrigation) projects, without integrating other needs and without considering other options. In the CWC Guidelines of 1991, 10 percent of available water is required to be allocated for domestic water supply in the command area of the project. This stipulation is not fully integrated in the design of the project. Also, there is little flexibility in accommodating other priority needs which were not foreseen at the time of project planning. Projects in water resources sector need to fully provide for domestic water requirements in the command area and should also have necessary flexibility to accommodate unforeseen priority uses of water.

Dependability of Deliveries and Carryover

Water projects, and reservoir projects in particular, have to face varying availability of inflows both within a year and from year to year. The reservoirs change these variable inflows into a more acceptable pattern of outflows within the constraints of available storage capacity and demand. Thus, the planned annual use, the planned capacity and the reliability or success of deliveries of water are all related to one other. Given the reservoir size, if planned annual use is raised, the success of delivery will be reduced. There are social aspects to this, such as the need for averting risks for small farmers, acceptability of irrigated agriculture with lower reliability etc. Considering this,a practice has evolved, and is now generally prescribed, that deliveries of irrigation water be planned at 75 percent reliability.

The requirement stated above does not prescribe how deliveries can be made more dependable, and in particular, whether the water available in one water year will be utilized for deliveries only in that water year or whether it can be stored, carried from one year to another through "carry over" or "over the year" operations. If the dam site has good geological and topographical features, larger storage and carry over options would be favoured During the early days of Krishna and Godavari disputes, directions were issued prohibiting planning of such carry over operations beyond a small minimum. The second Irrigation Commission in 1972, after discussions refrained from giving such recommendations and only recommended that deliveries should have a reliability of 75 percent. However, certain further directives of the then Ministry of Irrigation and Power (Oct. 1983) were not very clear and a confusion in this regard continued with a strong perception that carry over developments are not preferred. These issues have recently been discussed in a Workshop organized by the Indian Water Resources Society in Delhi during April, 1999. There are strong arguments favouring acceptance of lower dependable deliveries in drought prone areas, but the overall consensus appears to be against diluting the requirement of dependable deliveries. At the same time it is recognized that if carry over storages are not possible, there could be a "wastage" of water through spills in reservoirs in three out of four years and that this may not be a proper strategy. Strategies are available for larger and more optimum utilization not only through carry over storages, but also through an appropriate conjunctive use in which ground water storage provides the carry over. Again, benefits of irrigation could be substantive even if the reliabilities are maintained in one crop season (*say* Kharif) and other crop seasons are allowed to have larger risks. This approach has been used in a number of medium irrigation projects in the comparatively dry areas of Gujarat, and this change in the reliability concept can be useful in other similar areas. In general, a clear statement of policies, prescribing a general output related dependability of 75 percent and allowing innovative flexibilties in this regard and also favouring carry over development, is required.

Conjunctive Use

Larger conjunctive use of surface and ground water and their interaction needs to be incorporated more effectively in the planning practices. INCID & CWC have already issued guidelines in this regard. The extent of their implementation and effectiveness has to be studied for improving the technique.

Larger Use of Water Lifts

The planning process of surface irrigation projects was developed historically in environments where power for sizable lifts was not available. Projects are planned to allow gravity flow for *say* 200 km for downstream use, but do not cater to even small (*say* 30 m) lifts from the reservoirs and head reaches of canals. Apart from creating local ill-feeling, economically more attractive alternatives are sometimes thus left out. Lifts from a reservoir can sometimes bring benefits even to communities which are affected by the project.

Flow Capacity Redundancy

In lower lifts of the irrigation networks, the channels and outlets have a minimum capacity of about 30 litres per second (l/s). This is so because of two factors :

(i) In normal (furrow) irrigation of lands with low slopes, a discharge less than 15 l/s is incapable of irrigating the whole breadth of the field (or length of the furrow). Thus, if a dose of 6 cm of irrigation is to be provided to a 1 ha plot every 10 days, this will require a flow of 30 l/s for about 6 hours. The irrigation cannot, however, be done by providing the same volume of water through a flow of *say*, 3 l/s for 60 hours, since this flow would be lost through seepage in the furrows.

(ii) Also, the minimum practicable size of open field channels as can be constructed would have a capacity, at a reasonable velocity for carrying a discharge of this order (carrying of flows of smaller order is, however, possible, if pipes are used).

In order to maintain a flow of the order of 30 lit./sec., in each element like an outlet serving 5 to 8 ha or field channels serving say 2 ha, both rotation and time sharing are introduced and the lower elements function only for short periods. Thus, in a typical irrigation project, the capacities of all outlets at field channels taken together could be say four times and eight times more than the main canal capacity. Distributories and minors also may function for only half the time for which main canals function, and may roughly have an aggregate capacity twice that of the main canal. This practice costs money and additional land. There is need for rethinking on such practices. Larger use of pipes, keeping more number of elements in the continuous flow mode, coupling of drip and sprinklers with piped distribution, Structured Irrigation (gate less) system below distributory or minor, use of off line storages, use of surge irrigation to increase instantaneous discharges in pulses etc. are technologies that are now available and need to be further developed and incorporated in project planning.

Optimising Project Size

Economic analysis could serve two purposes. One is to determine the viability of the investment and the other is to decide about the size of the project, preferably through an optimisation procedure. The second aspect has not been well ingrained in project planning procedures in India. Procedures need to be adopted for optimisation of project size, specially for larger projects.

Benefit Cost Analysis

Benefit Cost Analysis is a powerful tool for determining the economic viability of a project. However, in the application of this method to water resource projects, the procedures laid down have been so over - simplified as to reduce this powerful tool into a routine computational exercise. This situation needs to be changed. A "Committee to Review the Existing Criteria for Working out the Benefit Cost Ratio for irrigation Projects" (Nitin Desai Committee) was set up in 1983 by the Planning Commission. The Committee made the following recommendations among others:

- A coordinated approach was required to improve the data-base and method of analysis.
- There was a need for techno-economic analysis to establish technically feasible alternative plans of utilization in the light of the specified objectives.
- A comparison of 'With' and ' Without' the project situation to find out the net additional benefit attributable to irrigation was desirable.
- All benefits and costs within the project area or in the surrounding areas on upstream or downstream which arose because of the projects had to be taken into account.
- The goods and services which were part of the project needed to be valued in terms of real costs incurred in supplying them or their value in other uses.
- For evaluation of benefit cost ratio, the discounted cash flow method was to be followed.

The Committee suggested a detailed case study to facilitate understanding of the methodology. The detailed case study has not been made so far.

Apart from the pendency of the above recommendations, the existing procedure of project appraisal has a number of shortcomings, some of which are discussed here.

The simplistic benefit cost procedures deal with surface irrigation projects. Water supply, both urban and rural, has somehow been kept outside the economic analysis.

In regard to hydro power, the general international practice is to include the cost of the alternative (thermal) as the benefit of the project. This allows the concept of firm power to be well established, capital cost of thermal alternative for the firm power to be worked out and the operational costs to be decided through the energy potential of the hydro power. The current procedures compute the benefits in terms of the revenue from hydropower supply.

Flood control projects often are projects for redistribution of economic benefits. When certain pockets have large flood related risks, investments in infrastructure development or industries would shy away from these areas and go elsewhere where such risks do not exist. This leads to endemic backwardness in areas subject to frequent flooding. The existing procedure is based upon the present status of development as the starting point and uses the "before" and "after" approach, instead of the more appropriate "with" or "without" approach. The present procedures also do not favour use of shadow prices, where, for obvious reasons, prevalent prices are distorted.

We recommend that the Planning Commission be requested to lay down an improved benefit cost analysis procedure, after considering all relevant aspects, namely technical, financial, economic, social and environmental.

10.3 Project Approval

Techno - economic appraisal of the project is necessary for obtaining investment clearance from the Planning Commission. Project specific funding by the state is not obligatory as funds for the sector are allocated as block grant. The process of project appraisal before the investment clearance involves:

- Detailed investigation and design by the state government and preparation of a detailed project report (DPR) as per guidelines of the Central Water Commission;
- The detailed project report is examined by various agencies and departments of Central Government and their observations and suggestions are incorporated by the state government and a Modified Report is prepared;
- The Advisory Committee for Irrigation, Flood Control and Multi-Purpose Projects (TAC), under the chairmanship of Secretary, Ministry of Water Resources, considers the technical note on the Modified Report for assessing and accepting the techno-economic viability of the project.
- Separate concurrence from the Ministry of Environment and Forests for clearance from environment and forest angles, and from the Ministry of Social Welfare for clearance from the rehabilitation angle of tribal population are required.

The assessment of techno- economic viability by TAC, clearances from Ministry of Environment and Forests & Department of Social Welfare, and investment clearance by Planning Commission are handled sequentially. Even though representatives of all the concerned Ministries, Departments, Planning Commission and State Governments are members of the TAC, because of the requirement of mandatory clearance by the Ministry of Environment and Forests and Ministry of Social Welfare, their participation in the committee tends to be formal. It is necessary that participation in TAC of all concerned is effective so that further delay in giving the mandatory clearances are avoided.

As regards medium projects, we have made separate recommendations in Chapter – 8.

10.4 Project Implementation and Management

There are several practices in project implementation that came in the way of timely completion. Implementation is started in many cases before techno-economic viability is established. Allocation of funds and starting of works before getting TAC approval commits the state government to the project, even though it may not be found to be viable later on. Technical changes and changes in scope become necessary delaying the project and increasing costs. As stated in Chapter – 9, under the scheme of project – financing proposed by us, it should be ensured that such practices are discouraged.

It is not as if the desirable practices are not followed in all cases. In externally funded projects, detailed appraisal, establishment of techno-economic viability, regular monitoring of physical and financial progress as well as of rehabilitation and resettlement, project- specific funding and funding in accordance with project programming schedule are all being done. There is no reason why all this should not be done in the case of other projects funded under the plan. It is for the Planning Commission to insist on all this while releasing funds for the projects (Chapter – 9).

For speedy completion of some large projects, Control Boards and Corporations have been tried. Experience of these Boards and Corporations have to be evaluated in detail. Prima facie, it appears that if certain essentials are taken care of, such special organisations would help in accelerating project implementation. In the case of large state projects, it may be worthwhile to go in for Joint Corporations (centre-state/s), with a Memorandum of Understanding (MOU) amongst the concerned parties. Efforts should be made to arrive at agreements in the case of selected projects for such joint management.

Water resources projects involve commitment of large funds, execution of large civil and mechanical works and management of a large labour force. In the early days of execution of large public works in India, works were often done through a number of small contractors, having limited technical skills and that too in a single discipline, and having hardly any managerial skills. The next logical evolution was the system of awarding large number of trade-wise competitive bids. Although the size of contracts in water resources projects has grown, they still follow this principle of dividing the work in a large number of small and some times trade-wise components. The awards are normally made through "item rate" bidding in which the contractor specifies rates for all major items of work and the work is awarded to one whose overall cost is the lowest.

The presence of a number of contractors on the site creates many problems of inter-facing and coordination. The contract documents are generally perceived to be extremely one sided in favour of the department, where the engineer in-charge is a party to the contract - a decision maker and the pay master and also the arbitrator in the case of a dispute. On the other hand, the discretion space available to the engineer in-charge is heavily curtailed through departmental circulars and any admission by him of the contractor's claims is also often viewed with suspicion. The engineer, therefore, tends to be partial to the department, on record, leading to dissatisfaction of the contractors and delays. "Extra items" and "new items" also lead to problematic decisions. A large number of contracts end in arbitration and litigation. Knowing that dispute is inevitable, preparing grounds for arbitration becomes a pre-occupation for both the parties.

In most of the advanced countries, the trend is towards giving larger responsibilities to the contractors and making contracting agencies into capable construction management agencies with multi-trade skills. Public bodies do not support the contractors through large advances or through giving material and machineries of the department for use by the contractor, but support the growth of construction companies by paying reasonable prices and encouraging competition amongst financially and technically sound contractors. This requires a very careful screening of the contractors' capabilities on the basis of past turnover and past performance. Such large contracts are given sometimes in the EPC mode where the contractor does the engineering, procurement and construction and requires little technical support from the owner. The quality control checks are done either by the owner or through a separate contractor. Payments are based not so much on the running bills of the quantities but on a pre-determined schedule linking project milestones with payments. Sometimes, contracts would be based on the owner's design but with procurement and construction responsibilities of the contractor. In any case the contractors have to provide considerable finance for construction as opposed to the present public works system, where he works with minimum capital and depends on payment of the running bills. Such procedures would have to be increasingly adopted in India.

A large contract in water project would require the contractor to have skills in different types of works. Specialized construction companies may have to cooperate amongst each other by forming consortia or by signing agreements. These need to be encouraged in the contracting procedures.

When a large work like that of a complex hydro power scheme is contracted out, there is a very large monetary stake in its early completion. Instead of the department specifying the time of completion, this also could be left to the contractor. The contract document can specify the equalizing formula in which the guaranteed saving in time can be converted in monetary terms for inter-comparison. Such procedures are common in other countries, say, for construction of roads and bridges . Such practices also need to be encouraged in India.

In short, the speedy completion of water projects is linked with the government changing its procedure in such a way as to support the development of large and competitive contracting firms. The public bodies have to cater to the larger objective of promoting the growth of a strong competitive construction industry and have to curb and curtail the tendencies and practices of trying to reduce cost on paper through unmanageable fragmentation of works and through unnecessary negotiations. In general, changes are indicated regarding the following:

- Contract documents and contracting procedures.
- Prescribing much stiffer pre-qualification requirements and allowing only the financially and professionally capable contractors to bid (However, changes in this regard may have to be phased, since a sudden change may reduce the competition).
- Much reduced day to day role of public works engineers in contract management.
- Ensuring comparatively larger packages and avoidance of the need for the department to co-ordinate amongst numerous small contractors.
- Avoiding the supply of material and machinery by the department to the contractors.
- Larger use of Turn key contracts.
- Larger use of E.P.C. type contracts.
- A much faster and impartial dispute settlement mechanism.
- Much larger transparency.

Efforts in these directions are on. The Commission is aware of the work being done by the Construction Industry Development Council and the recent guidelines of the Central Vigilance

Commission, restricting negotiations etc. These efforts need to be continued and operational procedures need to be changed substantially.

I. Prioritisation of Projects

10.5 Need for Prioritisation

Our review and analysis of the development of water resources through large projects brings out the following : Over the plan period, a large number of major, medium and minor schemes were taken up with a view to achieving the desired irrigation potential within a time bound framework and to simultaneously fulfill the food-fodder requirements of the growing population of the country. However, most projects could not be completed in time. The number of new projects taken up in the various Five Year Plans was much more than the projects completed. New projects were taken up by the state governments to satisfy the desires of local groups and local areas, while there has been gradual decline in the funding of Irrigation Sector over the various Five Year Plans. Thus, the general decline in the priority given to the water sector in the plans, coupled with the increase in the number of on-going and new projects, led to thin spreading of limited resources. The cost escalation factor also became very important and the spillover cost of the projects at the end of each plan remained almost the same or even higher.

There is thus an important need for prioritsation of ongoing and new projects. The schemes to be taken up are to be identified and suitable guidelines framed so that investments planned for the sector are utilised for deriving optimum benefits. It is also emphasised that investment on a project can be judiciously phased. This aspect is of great importance and needs to be examined in depth for each of the ongoing and new major schemes. Phasing of projects would enhance the prospects of covering more projects as well as reaping benefits at shorter intervals of time.

A review of the status of irrigation potential of on-going projects indicates that against the ultimate irrigation potential of 25.6 Mha of on-going schemes, the potential created upto the end of the Eighth Plan was only 9.15 Mha. (Table 10.2). Thus, adequate and judicious expenditure on prioritised on-going projects, before new projects are taken up, would help in early creation of substantial irrigation potential.

Table - 10.2

Status of Irrigation Potential of Ongoing Schemes

Category	Ultimate Irrigation Potential (Mha)	Irrigation Potential Created upto March,1997 (Mha)
Major	22.80	7.98
Medium	1.46	0.42
ERM	2.11	0.75
Total	**25.65**	**9.15**

Source: Compiled from CWC data.

Total potential created, through 75 major and 143 medium projects completed during the preplan period, was 9.7 Mha. The lack of required maintenance due to insufficient Non-Plan funds would make it necessary to examine the status of these completed projects and priority be given to the projects needing rehabilitation by way of providing adequate plan funds.

All funds allocated to a state project pass through the consolidated fund of the state. The budgets allocated to the projects by the state are within the legislative competence of the state's legislature and the preparation of the budget as well as its implementation is done by the executive wing of the state government.

Since the ability of the states to raise funds through fiscal measures is limited and since central government has larger ability to raise resources through taxation etc., the common pool of central taxes is divided between the states and the centre. With regard to the non-plan expenditure, the Finance Commissions lay down the procedures for sharing of revenues between the centre and the states. Central Plan Assistance to the states is determined annually through well established procedures, taking into consideration the population, the backwardness and special needs of the states. The share of the plan funds allocable to a state from the centre together with the plan funds available from state's own resources are then divided among sectors and further into projects. The sectoral allocations are decided jointly by the Planning Commission and the states, depending on the demands, the shelf of projects awaiting the funds, the perception of the problems in executing the schemes etc. At present, earmarking of funds by the Planning Commission against a project (in a way such that the state cannot re-appropriate these funds) has been narrowed down to a small proportion of total funds and to a very few projects selected from all the important sectors. Thus, while the Planning Commission has some say in the sectoral allocations of a state plan, it has little say in the projectwise allocation of the water sector funds amongst the shelf of such projects . We have dealt with this question in chapter - 9 of this Report and suggested a change to project wise funding in the case of major projects.

The state governments are perhaps under pressure to thinly spread the available resources for a variety of reasons, some of which are:

- There are demands for either removing regional imbalances within the state (by providing larger allocation to the regions not having much irrigation) or in maintaining an equity in allocation amongst regions. Similarly, some projects benefiting the tribal population require higher fund allocation;

- When the government changes, there is a tendency to change the priorities of the earlier regime;

- Perhaps the bureaucracy develops vested interests in projects and allocates inadequate funds for works (over and above the establishment cost which is some how considered as inescapable). Also, if any project is considered to be of comparatively low priority and is not given equitable funds, the staff on the project would have hardly any work, while if the funds are spread over all projects, all staff would be in a similar state of insufficient work. Since the perceived importance and satisfaction of the project staff is some times linked with the budget allocated to the project, there are internal pressures for such equality achieved through thin spreading ! ;

- Sometimes shifting away of staff from a project unlikely to be funded is taken by local people as a signal of neglect of the area. The state governments perhaps prefer to avoid such situations in the short run and prefer the policy of thin spreading, in spite of its 'long run' non sustainability;

- Sometimes, because of inter-state issues and likely effect of the project status on the decisions on the issue, the state wants to give an overriding priority to a quick start and / or quick completion of a particular project or projects.

- In addition to these, the availability or closure of external assistance could also be playing a role in this process.

So far no state has laid down any Principles or Approach for prioritisation of projects as a part of a self regulating mechanism. It is, therefore, necessary in public interest to lay down such principles. Apart from meeting the national interest, it would also assist the states in providing a stable policy framework . However, the approach has to address the issues of development and needs to adopt both flexible and pragmatic principles.

10.6 Guidelines for Prioritisation

After detailed consideration, the Commission adopted the following general principles for evolving the guidelines for prioritisation :

- The guidelines need to be simple.
- All projects meeting a threshold of acceptability as reflected in the techno-economic clearance should be considered as candidates for prioritisation.

- The prioritisation of schemes may give some advantage to ongoing projects but need not eliminate new projects altogether. Such of the new projects which are so good that, inspite of the advantage given to ongoing projects, they are up on priority, deserve to be implemented.

- Prioritisation would be on the basis of performance in terms of separate attributes none of which needs to be made as an 'ensured attribute'.

- Funds should be allocated strictly in the order of priority. Only after meeting all practicable requirements of high priority projects, funds may be allotted to the lower priority projects.

As regards methodology, the following stages are considered to be appropriate:

Stage I : (The Elimination Stage)

Eliminate projects not approved by Technical Advisory Committee, that is from the techno-economic angle.

Stage II : (The Classification Stage)

Externally aided projects as a group will have to receive larger funds than the rest. This is considered desirable in order to meet the counterpart commitment of the state in regard to such funding. Externally aided projects would have passed through higher standards of scrutiny and appraisal, and hence could be considered a priority as among the high ranking projects. Externally aided projects also give additionality to the available resources of the state. Considering this, the total available budget would have to be divided between two groups, namely externally aided projects and other projects, and the prioritisation process (Stage III and IV) would have to be undertaken separately for each of these groups.

Stage III : (Prioritisation)

Prioritise all approved projects whether continuing or new, at whatever stage of the completion through a single system having specified components, with marking for attributes. The system would consist of

- Deciding the desirable attributes of a project, which will allow a project to receive a high priority.
- Decide the inter-se importance of each attribute and assign the maximum of allocable points to each attribute to reflect the related importance.
- Analyse each project, attribute wise. Assign 'marks' to each project, from among the maximum allowable marks. As far as practicable, make this system "Objective"
- Add the marks obtained by a given project over all the listed attributes to arrive at the total.
- Decide the inter-se priorities of the projects strictly in terms of the total marks obtained.

This system should help to determine the order of priority, but no project will get eliminated because of its poor fulfilment of any given attribute. Also, no single attribute would have an overriding importance beyond that reflected in its inter-se importance.

Stage IV : (Deciding the Quantum of Funds)

The project on top of the priority list should receive full funding as required for its completion, constrained only by the organisation's capacity to spend the money efficiently and effectively. Only after meeting all requirements of a higher priority project, the requirement of the low priority project would be considered. However, as a concession to practicability, it would be ensured that all approved ongoing projects receive at least a small amount of the plan fund required for maintenance of the assets created through the partially constructed projects. This would ensure that projects 'deferred' in the priority programme due to their low priority and non-availability of resources are not 'abandoned'.

10.7 Attributes in the Guidelines

The desirable attributes of projects for receiving priority could be i) Advance stage of construction, ii) efficiency of remaining part of the project in creating residual benefits at low residual cost, iii) projects addressing regional imbalances like Irrigation Inequalities, iv) need for developing benefits for tribal inhabitants in the command, v) drought prone areas, vi) inter state aspects, vii) projects with bulk water supply (BWS), viii) projects with no change in scope, ix) formulation and management of Environment/Forest/R&R Action Plan, x) simultaneous planning and design of secondary canal network, xi) Multipurpose projects, xii) submission of revised estimates, xiii) Geological, xiv) Design and xv) Quality control Infrastructure at field level. In addition to the above attributes, state government could have special weightage for locally important attributes decided by a documented and notified State Policy.

The total of 100 'marks' are to be divided amongst these attributes in accordance with their inter-se importance. Also, under each attribute, as stated earlier, the method of giving marks to a project is to be devised. At the instance of the Commission, the concerned Working Group did a detailed illustrative exercise on the on-going projects in two states, namely Madhya Pradesh and Maharashtra after developing a computarised Excel Programme. The marks allocated by the Working Group to each of the attributes are given in Table 10.3. The results of prioritisation based on this exercise are annexed as Table 10. 4 and Table 10. 5 for the States of Maharashtra and Madhya Pradesh respectively.

Table - 10.3
Attributes with Corresponding Points

S. No.	Attributes	Points	Remarks
1.	Low Residual cost	20	
2.	Efficiency of Residual Benefits/Residual		
	Unit Cost	15	
3.	Inter State Projects	5	
4.	Discouraging change in Scope	5	
5.	Progress of Environment/Forest/ R&R Action Plan	5	
	a) Negligible progress - 0 Point		
	b) Partial progress - 2.5 Points		
	c) Desirable progress - 5 Points		
6.	Availability of simultaneous detailed		
	planning &design of Secondary Canal system	5	
7.	Infrastructure for Geology	2	
8.	Infrastructure for Quality Control	2	
9.	Infrastructure for Design (project site)	2	
10.	Timely submission of Revised Estimate	2	
11.	Multipurpose Project	2	
12.	Group of Attributes of Local Importance	35	Distribution of
i)	Regional Imbalances		these points
ii)	Projects with Provision of Bulk (Drinking) Water Supply		amongst sub-
iii)	Projects Serving Areas with Poor Quality Ground Water		attributes to be
iv)	Projects Benefiting Tribal Population		decided by the
v)	Projects Benefiting Drought Prone Area		State Govt.
vi)	Projects Involving Tribunal Awards		
	Total	**100 Points**	

Table 10.4 : Illustrative Excercise on Prioritisation of Projects - Maharashtra

STATE : MAHARASHTRA

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Sl. No.	Project Name	Total Points	Expn Upto Mar-97	Spill over Cost w/o esc	Proposed IXPlan Outlay by State	Spillover Cost Mar-97 Price	Inflated Cost 8 % p.a. 5 Years	Cumulati. Outlay Required	Min. Exp. for Maintenance	Max. Expend Capacity	Max. (Col.F-Col.K)	Min. (Col.H-Col.L)	Cumulative	Spillover Cost of Projects being deffered	Recommended IX Plan Outlay
1	Arunawati	52.15	126.22	40.23	21.58	50.00	60.00	60.00	2.16	197.70	197.70	60	60		60
2	Khadakwasla	44.62	221.04	120.43	75.13	120.43	144.52	204.52	7.51	703.58	703.58	144.52	204.52		144.52
3	Chaskman	40.59	128.92	172.74	146.92	211.64	253.97	458.49	14.69	228.25	228.25	228.25	432.77		228.25
4	Surya	42.11	157.94	68.30	8.49	96.31	115.57	574.06	0.85	170.98	170.98	115.57	548.34		115.57
5	Kadwa	41.31	48.84	27.16	0.00	38.67	46.40	620.46	0.00	86.85	86.85	46.40	594.74		46.4
6	Jayakwadi(I&II)	40.61	650.73	146.14	100.00	272.20	326.64	947.10	10.00	367.93	367.93	326.64	921.38		326.64
7	Upper Wardha	39.72	247.68	210.22	182.27	329.29	395.14	1342.25	18.23	192.26	192.26	192.26	1113.64		192.26
8	Bawanthadi	33.34	33.75	111.27	34.01	135.13	162.16	1504.40	3.40	53.28	53.28	53.28	1166.92		53.28
9	Vishnupuri	37.16	127.04	96.75	66.85	118.28	141.93	1646.34	6.69	112.75	112.75	112.75	1279.67		112.75
10	Kukadi	34.74	415.21	501.53	0.00	606.85	728.22	2374.56	0.00	220.30	220.30	220.30	1499.97		220.3
11	Waghur	29.72	34.74	74.66	74.59	115.64	138.77	2513.33	7.46	71.43	74.59	74.59	1574.56		74.59
12	Lower Terna(Flow)	31.30	111.38	53.83	27.16	83.73	100.48	2613.81	2.72	110.75	110.75	100.48	1675.04		100.48
13	Wan	26.01	95.63	39.99	40.10	105.05	126.06	2739.87	4.01	136.78	136.78	126.06	1801.1		126.06
14	Tillari	29.61	78.84	346.66	65.00	420.54	504.65	3244.52	6.50	144.68	144.68	144.68	1945.78		144.68
15	Bhatsa	28.91	66.19	330.96	151.60	355.77	426.92	3671.44	15.16	78.55	151.60	151.6	2097.38		151.6
16	Upper Prawara	24.77	36.78	299.09	107.79	401.12	481.34	4152.78	10.78	65.83	107.79	107.79	2205.17		107.79
17	Upper Penganga	27.57	391.16	475.84	335.89	731.66	877.99	5030.77	33.59	436.98	436.98	436.98	2642.15		436.98
18	Nandur Madhmeshwar(N)	21.80	53.00	232.15	102.20	281.83	338.20	5368.97	10.22	107.43	107.43	107.43	2749.58		107.43
19	Upper Godavari	23.96	87.39	97.61	40.84	118.55	142.26	5511.22	4.08	67.23	67.23	67.23	2816.81		67.23
20	Bhima	23.52	608.43	404.25	380.10	497.56	597.07	6108.30	38.01	689.65	689.65	597.07	3413.88		597.07
21	Upper Tapi	23.18	94.34	77.79	17.21	104.90	125.89	6234.18	1.72	36.10	36.10	36.10	3449.98		36.1
22	Krishna	21.77	248.90	97.61	180.32	120.94	145.12	6379.30	18.03	407.23	407.23	145.12	3595.10		145.12
23	Punad	21.25	27.57	88.05	70.72	122.19	146.62	6525.93	7.07	63.65	70.72	70.72	3665.82		70.72
24	Talamba	21.24	8.10	313.84	10.00	379.76	455.71	6981.64	1.00	3.25	10.00	10.00	3675.82		10
25	Lower Dudhna	18.80	17.74	243.26	110.00	326.33	391.60	7373.24	11.00	42.43	110.00	110.00	3785.82		110
26	Gosikhurd	18.55	194.01	1897.12	1895.70	2540.44	3048.53	10421.76	189.57	10.90	1895.70	1895.70	5681.52	0.00	1316.76
27	koynakrishna	15.56	321.64	999.57	0.00	1220.31	1464.37	11886.14	0.00	251.05	251.05	251.05	5932.57	1895.70	174.38
28	Warna	15.13	220.44	365.41	551.00	670.09	804.11	12690.24	55.10	182.65	551.00	551.00	6483.57	251.05	382.73
29	Dudhganga	11.57	161.43	541.83	489.93	657.31	788.77	13479.02	48.99	165.33	489.93	489.93	6973.5	551.00	340.31
	TOTAL		**5015.08**	**8474.29**	**5285.40**	**11232.51**	**13479.02**		**528.54**	**5405.71**	**8183.09**	**6973.50**		**3187.68**	**6000**

F	Outlay Proposed by State & recommended by W.G. of P.C.
H	Inflated Cost is estimated as 8% annual inflation over 5 years,i.e., mid point of 5 years =1.2*col. G
J	Min required outlay for maintenance of created assets taken as 10% of expenditure upto 3/97
K	Max expenditure capacity of the project organisation which is 2.5 * expenditure during VIII Plan
L	Ist step for outlay as Max. of Col.-F & Col.-K
M	**IInd step Required outlay as Min of Col.-H & Col.-L**
P	Recommended outlays for approved projects decided as per Col. M, Untill Cumulative Outlay (Col. N) tends to exceed 80% of outlay. As per col. M Beyond this the projects are considered as deferred projects. The total fund required (i.e. total of Col. O) as 3187.68 compared with residual fund availability (6000-3785.82), and allocation is made prorata i.e. Col.O*2214.18/3187.88

Table 10.5 : Illustrative Excercise on Prioritisation of Projecs - Madhya Pradesh

STATE : MADHYA PRADESH

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
Sl. No.	Project Name	Total Points	Exp. upto Mar-97	Spill over Cost w/o Esc	Proposed IX plan Outlay by State	Spill over Cost with Esc	Inflated Cost	Cumula-Outlay Required	Min Exp. for Maintenance	Max. Expend. Capacity	Max. (Col.F-Col.K)	Min. (Col.H-Col.L)	Cum.	Spillover Cost of Projects being deffered	Recomm-ended Outlay for deffered Projects	Recomm-ended Outlay Ist Step	Outlay for deffered Projects Min. Exp. For Maintenance	Spill over cost With Inflation remaining for deffered Projects	Outlay for reamaining deferred Projects	Recommended IX Plan Outlay for Ongoing Projects
1	Raghat Unit - II	137.08	101.19	422.22	289.32	512.04	614.45	737.34	10.12	136.08	289.32	289.32	289.32			289.32				289.32
2	Kolar	50.70	165.09	19.91	0	24.43	29.32	766.66	16.51	96.83	96.83	29.32	318.64			29.32				29.32
3	Upper Wain Ganga	44.87	156.97	37	19	51.58	61.89	828.55	15.70	90.45	90.45	61.89	380.53			61.89				61.89
4	Raghat Unit - I	38.99	89.83	43.67	5	64.79	77.75	906.30	8.96	45.38	45.38	45.38	425.91			45.38				45.38
5	Thanwar	41.00	22.64	4.56	0	5.58	6.70	913.00	2.26	7.98	7.98	6.70	432.61			6.70				6.70
6	Kodar	40.37	30.82	3.8	2.78	3.80	4.56	917.56	3.06	18.78	18.78	4.56	437.17			4.56				4.56
7	Sindh Ph. I	40.32	41.77	14.58	4.65	30.03	36.04	953.59	4.18	27.55	27.55	27.55	464.72			27.55				27.55
8	Ban Sagar Unit - II	34.55	130.64	407.12	20	737.26	884.72	1838.31	13.08	97.68	97.68	97.68	562.40			97.68				97.68
9	Mahi	34.30	41.99	150.86	0	150.86	181.03	2019.34	4.20	34.23	34.23	34.22	596.62			34.22				34.22
10	Pairy	36.77	27.38	6.44	1	14.99	17.98	2037.32	2.74	19.65	19.65	17.98	614.60			17.98				17.98
11	Jonk	36.36	30.99	19	19.08	19.00	22.80	2060.12	3.10	23.70	23.70	22.80	637.40			22.80				22.80
12	Bawanthadi Unit - II	33.27	5.66	94.34	0	169.51	203.41	2263.53	0.57	12.58	12.58	12.58	649.98			12.58				12.58
13	Hasdeo Bango	36.26	565.88	292.43	105	594.74	713.69	2977.22	56.59	459.80	.459.80	459.80	1109.78			459.80				459.80
14	Man	34.36	64.07	44.13	61.5	53.62	64.35	3041.57	6.41	78.78	78.78	64.35	1174.13			64.35				64.35
15	Urmil	33.62	16.01	6	4	7.34	8.80	3050.37	1.60	15.05	15.05	8.80	1182.93			8.80				8.80
16	Jobat	33.51	26.44	70.48	50	85.49	102.59	3152.96	2.64	42.25	50.00	50.00	1232.93			50.00				50.00
17	Bhander Canal	32.78	6.71	2.78	4.56	5.73	6.88	3159.84	0.67	5.63	5.63	5.63	1238.56	0.00		5.63				5.63
18	Bargi	32.62	397.41	361.59	120.5	546.91	656.30	3816.13	39.74	306.03	306.03	306.03	1544.59	656.30	32.89	32.89	39.74			39.74
19	Ban Sagar Unit - I	29.55	339.75	596.25	105	1088.14	1305.77	5121.90	33.98	194.75	194.75	194.75	1739.34	1305.77	65.45	65.45		1305.77	64.02	64.02
20	Barna	32.26	27.55	3.7	3.62	4.48	5.38	5127.28	2.76	14.18	14.18	5.38	1744.72	5.38	0.27	0.27	2.75			2.75
21	Indira Sagar	28.20	228.72	1345.28	501	1345.28	1614.34	6741.62	22.87	346.98	501.00	501.00	2245.72	1614.34	80.91	80.91		1614.34	79.15	79.15
22	Bawanthadi Unit I, II	23.27	11.03	150.46	39	271.28	325.53	7067.15	1.10	25.90	39.00	39.00	2284.72	325.53	16.32	16.32		325.53	15.96	15.96
23	Bargi Diversion	26.23	21.15	1533.35	6.81	1855.48	2226.57	9293.72	2.12	32.98	32.98	32.98	2317.70	2226.57	111.60	111.60		2226.57	109.17	109.17
24	Bariarpur LBC	21.71	51.92	91.08	91.08	122.13	146.56	9440.28	5.19	42.43	91.08	91.08	2408.78	146.56	7.35	7.35		146.56	7.19	7.19
25	Sindh Ph. - II	21.65	109.99	497.68	0	914.26	1097.11	10537.39	11.00	181.70	181.70	181.70	2590.48	1097.11	54.99	54.99		1097.11	53.79	53.79
26	Pench Diversion	20.26	8.25	177.79	0	316.18	379.42	10916.81	0.63	7.13	7.13	7.13	2597.81	379.42	19.02	19.02		379.42	18.50	18.60
27	Omkareshwar	20.08	5.49	749.51	10.29	1207.91	1449.49	12366.29	0.55	9.13	10.29	10.29	2607.90	1449.49	72.65	72.65		1449.49	71.07	71.07
	TOTAL						12243.41				2751.53	2607.90		9206.46	461.44	1700.00	42.49	8544.78	418.95	1700

F	Outlay Proposed by State & recommended by W.G. of P.C.
H	Inflated Cost is estimated as 8% annual inflation of 5 years,i.e., 1.2*ColG
J	Min. Exp. of Maintenance considered as 10% of expenditaje incurred upto 3/97
K	Max. Exp. Capacity of the project organisation which is 2.5* expenditure incurred in VIII Plan.
L	Ist Step for outlay as maximum of Col. F & Col. A
M	Second Step for required outlay as minimum of Col. H & Col. L
N	Recommended outlay for approval projects as per Col. M until cumulative outlay (Col.N tends to exceed 80% of outlay) as per Col. M. beond this projects are considered has deffered pojrects and outlay as per correspondent col. O
P	Recommended Outlay for remaining deferred projects on prorata basis of spill cost & total spill cost i.e. Col. O-34 against balance fund required =(1700-1238.56-42.40) * 9206.46
R	Outlay recommended on the basis of min in expenditure for maintenance.
T	Recommended outlay for remaining deferred projects on pro rata basis of spill cost and total spill cost i.e. Col. S-34 against balance fund required (1700-1238.56)*8544.78
U	Recommended IX Plan outlay for approved project untill outlay exceed 80% upto corresponding upto Col. Q - 23 & Col. 24 onwards Max (Col. Q - Col. R) & Min. (Col. T - Col. P)

The Commission considered in detail, the attributes and the marking system and each of them is discussed below.

I. Advanced Stage of Completion(Low Residual Cost)

Projects in the advanced stage of completion do need to be given priority. This would also be in tune with the existing practice. It is felt that projects, on which the expenditure incurred is less than 50 percent of the current estimated cost, need not be considered under this attribute, that is, could be given zero point. For projects, where expenditure is beyond 50 percent, the marking would be linear (0 marks at 50 percent and full allocable marks at 100 percent).

II. Benefits from Residual Investment / Residual Unit Cost

A project may have come to a stage where the benefits from residual investment on the project would be much more than that in other projects. A little investment at the margin would allow achievement of a large amount of total benefits. On the premise of 'Sunk cost' such projects will have better productivity on the margin, and hence will qualify for highest prioritisation in funding. This attribute should, therefore, be given highest priority.

All the projects of the state could be listed in descending order of benefits per unit of residual cost. The project ranked first would be awarded the maximum points. The project ranked lowest would be given 0 point. Other projects will be given points on pro rata basis of benefits of the project, between the two limits. The reporting system for potential creation could vary from state to state. As the weightage points of projects for a particular state as a whole are being considered on proportionate basis, any anomaly in reporting system by the state would not effect the resultant weightage considered in this case.

III. Inter-State Projects

One of the shortcomings of our planning and development of water resources is the emphasis on intra-state efforts. Fuller and optimal use often requires cooperative action as reflected in an inter-state project. Although a large number of inter-state projects are under construction, these require further encouragement. Also, they have special problems of funding since any inter -state problem during execution gets reflected in funding. Their speedy completion is important and due weightage has to be given for this.

IV. Discouraging Change in Scope

Irrigation and water resources projects often undergo a large change of scope during execution. Often, the state does not even prepare the revised proposal, incorporating such changes. This creates numerous complications and needs to be discouraged. In view of this, it is proposed to allocate desired points to projects where either no 'change of scope' has taken place, or when a revised proposal incorporating the change is already submitted to the centre. Small changes in scope may be unavoidable. Wherever there is more than 10 percent change in any of the three important components, namely storage capacity, command area, capacity of main canal, the project needs to be revised. If this is not done, no marks would be given.

V. Progress of Environment/Forest/R&R Action Plan

Environment Management Plan, Afforestation Action Plan, R & R Action Plan have to go *pari passu* with implementation of the project. In case the progress on these plans is unsatisfactory, it will disrupt work and viable solutions will not be forthcoming. It would be desirable to give due weightage to differential progress. It is recommended that if the progress on these fronts is negligible, no marks will be awarded. For partial progress and satisfactory progress, corresponding higher points will be given.

VI. Availability of Simultaneous Detailed Planning and Design of Secondary Canal System

A project's primary aim is to quickly achieve ultimate benefits. Very often, the head works and even the primary network gets completed, but no potential is created since the construction of secondary network of distributories, minors and subminors is not taken up. This work, which requires detailed surveys and micro planning exercises, seem to be of low priority to project authorities, since costs and hardware components are less significant. This situation needs correction. Ground strategies for secondary canal network need to be tackled simultaneously. Simultaneous detailed planning/design of secondary canal system could result in achieving the desired results in time. It is, therefore, considered that requisite points be earmarked to the projects for which such detailed planning/design for secondary canal system is available.

VII. Infrastructure for Geology

Geological surprises are, to some extent, to be expected. This could hamper the smooth progress of work, if necessary support at site is not available. Therefore, points have to be awarded for having independent infrastructure for dealing with such surprises at field level, through the availability of competent geologists.

VIII. Infrastructure for Quality Control

Quality control of a project is one of the important pre-requisites for construction. It is always desirable to have independent quality control unit under the project. It has been felt that project with annual irrigation of less than 50,000 ha., greater than 50,000 but less than 4,00,000 ha and greater than 4,00,000 ha should have facility of independent quality control sub-division, division and circle respectively. The projects having independent quality control units could be considered for some points.

IX. Infrastructure for Design

One common defect in execution of projects is the lack of field level design support. This field level support is required both for site design of small structures, subsidiary works, design changes during construction etc., as also for liaison between the construction staff and the design organisation of the state. It could be in the terms of small designs unit or design liaison unit, either of the construction agency, or of the design office, or of the design consultant at the site. It is, therefore, necessary to earmark some points for availability of Infrastructure for Design at the field level.

X. Timely Submission of Revised Estimate

Projects continue to be implemented over the years based on earlier approved costs, so long as expenditure incurred to date remains within the limits of such approved costs. Updating is generally avoided. Updating of cost on regular basis is essential to ascertain the total and realistic needs of the project. Therefore, updating the cost and getting it approved periodically, preferably every year based on recognised inflation index and once in two years based on Schedule of Rates should attract points.

XI. Multipurpose Projects

Multipurpose projects envisage benefits, like power and flood control in addition to irrigation benefits. The cost of storage dam which is the common component is distributed proportionately to the benefited sectors, resulting in reduction of cost of irrigation component. It is, therefore, felt that some points may be earmarked for multipurpose projects covering irrigation component.

XII. Group of Attributes of Local Importance

Apart from the attributes discussed above, there are other important attributes relating to the general desirability of using projects as a means of removing or reducing inter citizen disparities and addressing local problems. It is felt that all these may be treated as a "Group of locally important attributes," and given bulk or total marks. The distribution of these bulk or total marks within the group may be left to each state government, with a rider that the state would do this within a somewhat consistent and clearly stated procedure as reflected in its administrative orders . A total of 35 marks could be earmarked for this group of attributes. Another rider would be that any of the attributes under this group would not be given more than 10 marks. The attributes identified by us are namely, i) Regional Imbalances ii) Projects with Bulk (Drinking) Water Supply, iii) Projects serving the area with poor ground water quality, vi) Projects benefiting Drought Prone Area, v) Projects benefiting Tribal Population & vi) Projects involving tribunal awards. The recommended approach for weightage of the aforesaid attributes should preferably be adopted as under :

Regional Imbalances : Regional imbalance in irrigation development is an important issue for consideration. The irrigation development status can be judged by the ratio of gross irrigated area to gross cropped area (irrigation intensity) of the region benefited by the project, in comparison of the corresponding ratio of Gross Irrigated Area to Gross Cropped Area (i.e. irrigation intensity) of the state. The scale would be as follows :

Ratio of (Regional) Irrigation Intensity to the (whole state) irrigation Intensity	Marks
Less than 0.5	Full marks
Between 0.5 to 0.75	75 percent of full marks
Between 0.75 to 1.0	50 percent of full marks
Greater than 1.0	No marks

Projects with Provisions of Bulk (Drinking) Water Supply : Highest priority is to be given, amongst various uses, for drinking water supply. Thus incorporation of domestic water supply in irrigation or multi-purpose projects is a desirable goal. It is normal to provide upto 10 percent of the total utilisation of the project for Rural Water Supply. Projects planned for larger water supply component have to be given higher priority, as under:

Provision of Rural Water Supply to Total Utilisation Under the Project	Marks to be Allotted
Less than 10 percent	Nil
Equal to or More than 20 percent	Full
Between 10 percent to 20 percent	Pro-rata

Projects Serving Areas with Poor Quality of Ground Water : In many areas, ground water has serious quality problem, such as occurrence of fluorides or arsenic. Since alternatives are not available, rural population has to continue using this ground water. Bringing surface irrigation to this area provides a better alternative even if expensive provision for replacing water supply source is not made. A few marks can be allocated for reflecting higher priority of such projects.

Projects Benefiting Tribal Population & Drought Prone Area : Irrigation projects particularly those benefiting Tribal Inhabitants and those benefiting Tribal Drought Prone Area (DPA) are important factors in achieving equity and giving special benefits to deprived communities or areas . The tribal inhabitants within the command, who are deprived communities, when benefited by the project, may be given due weightages points. Similarly, a project benefiting drought prone areas is an important factor and due points be earmarked suitably for this attribute. If the project is benefiting drought prone area (DPA)/tribal population partially, the weightage of points would be decided on proportionate basis with number of D.P.A districts/tribal population with respect to total number of districts/population benefited by the Project.

Projects Involving Tribunal Awards : Sometimes, water dispute tribunals, while allocating waters amongst the basin states, provide for a possible review of the allocation after a specified date. The states feel that if by the date specified for the review, they do not start utilising these allocated waters, or if they do not even create the engineering means for such a utilisation, their allocations may be jeopardised in a review. They may, therefore, wish to give priority to the completion of such projects by reserving some marks.

On the basis of these considerations, the Commission is of the view that points given by the Working Group to Residual benefits, Residual cost and progress of Environment/Forest/R & R Action Plan may be revised as follows:

Efficiency of Residual benefits/ Residual Unit Cost	-	20 points
Low Residual cost	-	10 points
Progress of Environment/Forest/R&R Action Plan	-	10 points

The points for the other attributes will remain the same as in Table 10.3

10.8 Methodology for Deciding the Quantum of Funds

As stated in Stage III above, the general approach to prioritisation is :

- Rank the project in descending order of priority.
- Allocate the full funds to the top ranked project
- Go to the next projects, if funds are available
- However, if most of the available funds are almost spent, go to the "thin spreading" mode in regard to a remaining project

As per above methodology, the main aim of prioritisation is to earmark specific outlay for the ongoing & new projects of a state. This approach leads to project specific funding.Working with this approach will require some practical guidelines in regard to a few items, which are indicated below :

- Interpretation of "Full fund required" : Full fund required for a project will be linked to spillover cost based on current estimated cost (or adopt escalation percentage if cost is on previous years of Schedule of rates). The inflation is also to be added on the spillover cost for the remaining period of completion.

- Spending Capacity : It is felt that expenditure incurred during earlier plan should form the base to ascertain the spending capacity of the project during the next plan. Considering the inflation index and working capability of project authority and considering the prevalent rates of inflation, it is considered that 2.5 times the expenditure incurred in the earlier plan could be adopted as spending capacity of the project in the next plan. This spending capacity could, however, be compared with the states' proposed outlay for the next plan and higher value of these two factors can be considered as the 'spending capacity ' of the project. This spending capacity would then be compared with the full fund required for the project as explained in the preceding para; the lower value between these two will be the recommended outlay for the projects of higher priority.

- Going to the "thin spreading mode" :"Thin spreading mode" for the remaining project is recommended to take care of the maintenance requirements of the created assets. It is desirable to first consider the identified projects starting from the top rank downward and provide recommended outlays until the cumulative amount reaches the major portion of total available funds, say 80 percent of total available outlay towards the sector. Thereafter, funds for the remaining projects will go to "thin spreading mode".

- How to Allocate Funds in the "Thin spreading mode" : The remaining projects of lower priority identified for thin spreading could be considered as deferred projects. Allocation of funds of such projects will be limited to balance amount that is about 20 percent of the total available outlay. This balance amount will be divided amongst deferred projects on prorata basis. For this purpose, the total funds available to all deferred projects can be compared with their full fund requirements, and the proportion worked out.

In this process, some projects may get very little fund, which may be too small even to meet the normal requirement for maintenance of the partly created assets. The minimum funds required in a five year plan for maintenance of assets created, can be taken as say one-tenth of expenditure incurred upto beginning of that five year plan. If the prorata fund on the principle of "thin spreading" as worked out for any deferred project is less than this maintenance requirement, it may be increased, where practicable, to the maintenance requirement, and a corresponding adjustment made in other deferred project.

Testing the Guidelines

The guidelines given above have been developed throughanessentially interactive and deliberative process by the concerned Working Group. This process involved the following stages :

- The Working Group on Prioritisation deliberated on the general philosophy.
- The desirable attributes were listed and draft guidelines for Prioritisation and funding were written down.
- Using these guidelines and using the data of two states, namely Madhya Pradesh and Maharashtra, a trial exercise about prioritisation and funding was made. This was made in the context of the funding of these states' programmes for the IX Plan
- The choice of these two states was made both considering the ready availability of information, and the divergence position as obtained. In general, Madhya Pradesh is a state where much thin spreading has occurred and the spillover cost is much larger than available outlays. In Maharashtra, the two are better balanced.
- The results of the initial trial exercises were studied by the Working Group, considering the reasonability and the general acceptability of the results.
- The results were also shown informally to senior representatives of the water resources departments of the two states. It was recognised that they need not be asked to present the formal reaction of the state to the proposed prioritisation. Instead, they were asked to indicate if, considering the attributes, approval in the priorities of funding as indicated by the exercise viz a viz those reflected in the states' proposed funding pattern, they would suggest any change in the scheme of prioritisation. Such differences were rather marked in the case of Maharashtra.
- After considering the views expressed by state officials, the Working Group decided to make a few modification in the draft guidelines.The revised draft of the guidelines along with the revised trials in respect of the two states was discussed by the Commission and some important changes were suggested. These changes were incorporated both in the guidelines and in the trial exercises. The guidelines, so evolved, are already described above.

The results of the final trial exercise as done for Maharashtra and Madhya Pradesh based on the points system adopted by the Working Group are presented in Tables 10.4 and 10.5 respectively.

We recommend that the Planning Commission and the Ministry of water resources should require each state to prioritise major projects on the basis of the above guidelines and the revised system of points recommended by us.

10.9 Phasing of Projects

Ongoing and new major/multipurpose schemes prioritised on the basis of suggested guidelines will automatically cover aspects of phasing of the water development programme in a particular state.

We have already discussed the need for operation research and system analysis for optimum project planning. These techniques can be used for deciding the optimum basin development and the sequencing of project implementation in an optimised manner. This is another possibility of phasing of projects.

Prioritised major irrigation & multipurpose schemes could be further phased for implementation. Where an irrigation project command extends to vast areas, it could be further sub divided into identifiable sub systems starting from headwork in upper reaches to tail reaches each covering about 10,000 ha. The work should preferably be completed in the order of sub-systems starting from headworks to tail reaches. This approach of phasing will help in achieving benefits commensurate to expenditure incurred on the canal network . This process would also curb the tendency of declaring the whole project as incomplete, even when the work left to be done is only in a small part of the command. Phasing should be supported by specific financial outlays for better monitoring and financial discipline.

Phasing of a large project through a phased programme of construction of the dam designed to achieve intermediate benefits is sometimes possible. Often, such phasing would involve the difficult problem of increasing the height of the dam in subsequent phases, widening of a running canal for increased discharge to the next phase . In view of these problems, such phasing is not favoured in many projects. However, where local circumstances allow such phasing, it needs to be considered for adoption.

CHAPTER – 11

INTERNATIONAL DIMENSIONS

India is drained by a number of international rivers that rise beyond its borders or flow into lower riparian states. Some of these constitute boundary rivers over parts of their length.

The co-sharers of these common rivers, many of them major waterways, number six: Nepal, Bhutan, China, Myanmar, Bangladesh and Pakistan. Obviously, therefore, national water resource planning cannot ignore this fact. Indeed, claims and counter-claims by the riparian states over the waters of certain trans-boundary rivers have resulted in delaying or modifying a number of projects.

11.1 International Convention and UN Framework Convention

International legal principles with regard to the navigational uses of international watercourses were codified and formulated relatively early, as cross-border inland navigation and timber floating were important to many countries. It was slower to develop with regard to non-navigational uses as water resource development entailing large storages and diversions was largely a product of nineteenth century technology. The verdicts of courts and tribunals in large countries with federal characteristics, like the United States of America and India, established a body of case law as a guide to action. For example, the Helsinki Rules of the International Law Association, a non-governmental body, won considerable acclaim when it was enunciated in 1966.

This, however, remained a non-binding convention though evolved by an influential professional body. This prompted the United Nations (UN) to attempt to codify a set of principles in relation to international water regulation. The International Law Commission (ILC) was assigned this task in 1970. After years of labour, it presented a Draft Framework Convention to the General Assembly, which finally adopted the Convention on the Non-Navigational Uses of International Watercourses in May, 1997 by 104 to three votes (including China), with 26 abstentions (including India and Pakistan). Bhutan was not present.

The Convention is open for signature until May, 2000. As of June 30, 1999, 11 countries had signed the Convention of which six had also ratified it. It has to be ratified by 35 signatories to come into force. Unanimity is hard to come by in such matters in view of the divergent views espoused by upper and lower riparians. Nevertheless, international conventions and legal principles are likely to assume growing importance in diplomacy and international relations in view of emerging regional water shortages and quality issues over large areas, affecting both surface and ground water systems in an increasingly globalising world.

The Convention seeks to codify state practice and sets out a number of established and evolving principles. We refer below to some of the salient points of the Convention:

- A "watercourse" means "a system of surface waters and ground waters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus". An international watercourse, in turn, is "a watercourse, parts of which are situated in different States". (This definition would apply to the Ganga-Brahmaputra-Meghna (GBM) system, though Bangladesh disputes this. Until the eighteenth century, the Teesta flowed into the Ganga and thereafter migrated to the Jamuna, then a spill channel of the Old Brahmaputra).

- Watercourse states are entitled to consultation and to participation in negotiations in good faith where their use of an international watercourse is "affected to a significant extent" by the actions of a fellow riparian (Article 4).

- An international watercourse shall be utilised in "an equitable and reasonable manner" with a view to attaining "optimal and sustainable utilisation thereof and benefits therefrom". This shall be done "taking into account the interests of the watercourse States concerned" and consistently with "adequate protection of the watercourse". Equitable and reasonable development and participation by watercourse states "includes both the right to utilise the watercourse and the duty to cooperate in the protection and development thereof"(Article 5). The emphasis on environmental protection and use of the term "sustainable utilisation" are new.

CONVENTION ON THE LAW OF THE NON-NAVIGATIONAL USES OF INTERNATIONAL WATERCOURSES

(Articles on Ecosystems and Pollution)

Protection and preservation of ecosystems (Article 20)

Watercourse States shall, individually and, where appropriate, jointly, protect and preserve the ecosystems of international watercourses.

Prevention, reduction and control of pollution (Article 21)

1. For the purpose of this article, 'pollution of an international watercourse' means any detrimental alteration in the composition or quality of the waters of an international watercourse which results directly or indirectly from human conduct.

2. Watercourse States shall, individually and, where appropriate, jointly, prevent, reduce and control the pollution of an international watercourse that may cause significant harm to other Watercourse States or to their environment, including harm to human health or safety, to the use of the waters for any beneficial purpose or to the living resources of the watercourse. Watercourse States shall take steps to harmonize their policies in this connection.

3. Watercourse States shall, at the request of any of them, consult with a view to arriving at mutually agreeable measures and methods to prevent, reduce and control pollution of an international watercourse, such as:

   (a) Setting joint water quality objectives and criteria ;

   (b) Establishing techniques and practices to address pollution from point and non-point sources ;

   (c) Establishing lists of substances the introduction of which into the waters of an international watercourse is to be prohibited, limited, investigated or monitored.

- Article 6 lists "factors relevant to equitable and reasonable utilisation". These include all natural factors and circumstances such as geography, hydrology, climate and ecology; social and economic needs; population dependent on the watercourse; the effects on other watercourse states; existing and potential uses; conservation, protection, development and economy of use of the water resources of the watercourse and the cost of measures taken to that effect; the availability of alternatives, of comparable value, to a particular planned or existing use; and the duty when need arises to enter into consultations in a spirit of cooperation. The weight to be given to each factor is to be determined "in comparison with that of other relevant factors", all relevant factors being taken together and a conclusion on equitable and reasonable use being determined "on the basis of the whole". The Rapporteur's commentary explains that these factors are only indicative and not exhaustive. Further, that "alternative means" implies not only other sources of water supply but also of other means, not involving the use of water, of meeting the needs in question, such as alternative sources of energy or means of transport.

- While no use enjoys any inherent priority over other uses, if there is a conflict between uses, then, "vital human needs" should prevail (Article 10). Drinking water and irrigation for food production would qualify as vital needs.

- There is an obligation to exercise due diligence through all appropriate measures to prevent causing "significant harm" to other watercourse states. Where, nevertheless, significant harm is caused or apprehended, consultations are enjoined "to eliminate or mitigate such harm and, where appropriate, to discuss the question of compensation" (Article 7).The commentary is again instructive. The Rapporteur opines that the principle of equitable and reasonable utilisation remains the guiding criterion in balancing the interests at stake, even when significant harm may be caused or claimed. He argues that "due diligence" suggests an obligation of conduct and not of result and cites Article 4 of the Indus Waters Treaty(1960) under which "each Party declares its intention to prevent, as far as practicable, undue pollution of the waters of the Rivers...." However, according to the Rapporteur, a use that causes significant harm to human health and safety is understood to be inherently inequitable and unreasonable. The phrase "significant harm" substitutes the earlier usage of "appreciable harm". This is to ensure objective measurement in place of subjective sentiment and as an aid to assessing the quantum of compensation.

- There is a general obligation to cooperate in good faith to attain "optimal utilisation" and "adequate protection". Establishment of joint mechanisms or commissions are suggested as means towards this end (Article 8). There is a more specific obligation to exchange a wide range of data and to cooperate in procuring it (Article 9).

- Other Articles deal with consultation and planned measures. Article 27 requires appropriate measures to be taken to prevent or mitigate harmful conditions resulting from natural causes or human conduct, including floods, waterborne diseases, siltation, erosion, salt water intrusion, drought or desertification and measures prescribed for emergency situations and in circumstances of armed conflict.

- A dispute settlement mechanism is spelt out in Article 33 through peaceful negotiations, good offices, mediation and concilitation or by arbitration or reference to the International Court. Issues unresolved for six months may, at the request of either party, be referred to impartial fact finding with one member drawn from either side. In the event of their being unable to agree on a neutral third party chairman, either side may call upon the UN Secretary General to make the appointment.

India abstained from signing the Convention on account of certain reservations, which are briefly mentioned below:

- Article 3, which deals with Watercourse Agreements, provides that 'an agreement may be entered into with respect to an entire international watercourse or any part thereof or a particular project, programme or use except in so far as the agreement adversely affects, to a significant extent, the use by one or more other watercourse States of the waters of the watercourse, without their express consent'. Regarding this Article, India believes that a Framework Convention should not be prescriptive but should leave states free to evolve and implement mutually agreeable terms in relation to specific international watercourses. Thus Article 3 fails adequately to reflect the principle of freedom, autonomy and the right of states to conclude international agreements without being fettered by the UN Framework Convention.

- Article 5 on Equitable and Reasonable Utilisation and Participation is not clear and unambiguous especially as the term "sustainable utilisation" has been imposed on the principle of optimal utilisation without defining what the former implies in the given context. Article 5 is, therefore, vague and difficult to implement.

- Article 32 dealing with non-discrimination presupposes political and economic regional integration of states, as say within the European Union. Otherwise, prescribing national treatment for non-nationals claiming recompense for alleged trans-boundary injury will be unimplementable.

- Finally, Article 33 pertaining to the settlement of disputes mandates an element of compulsion in setting up fact-finding commissions. India believes that the parties should be left free to choose any acceptable procedure for securing an amicable settlement through mutual consent.

Some of the language and concepts embodied in the Mahakali(India – Nepal) and Ganga (India – Bangladesh) Treaties bear resemblance to those found in the UN Convention. This is because these ideas and expressions were, in fact, drawn from the ongoing deliberations on the Draft Convention by the International Law Commission. One notable difference, however, lies in the use of the phrase "no harm" in the Mahakali and Ganga Treaties. The UN Convention instead refers to "no significant harm". The difference arose because the UN/ILC text was still under formulation when the two Treaties were signed. Should the meaning of "no harm" become the subject of dispute, the expanded UN definition would provide guidance.

Formula for Sharing the Lean Season Flows at Farakka
(Annexure – 1 of the Treaty)

Availability at Farakka	Share of India	Share of Bangladesh
70,000 cusecs or less	50%	50%
70,000-75,000 cusecs	Balance of flow	35,000 cusecs
75,000 cusecs or more	40,000 cusecs	Balance of flow

Subject to the condition that India and Bangladesh each shall receive guaranteed 35,000 cusecs of water in alternate three 10-day periods during the period March 1 to May 10.

The bilateral or regional treaties and understandings entered into by India with any of its neighbours will normally take precedence over the UN Convention, which is a framework to which India is not a signatory. However, although India abstained from signing the Convention, we could draw upon the principles enunciated in it usefully for the purpose of evolving an interpretative matrix not spelt out in our bilateral treaties.

11.2 Regional Issues

The issue of international water relations arose in an acute form immediately after 1947 with the partitioning of the Indus river basin and what had earlier been a single irrigation system in Punjab. It was settled through the Indus Waters Treaty (1960) which allocated the entire flows of the three Eastern Rivers, the Sutlej, Beas and Ravi, to India except for domestic use, non-consumptive uses and restricted agricultural use by Pakistan and that of the three Western Rivers, the Chenab, Jhelum and Indus, to Pakistan, less domestic use, non-consumptive uses and limited agricultural use by India. The Treaty also permits India to harness the energy potential of the Western Rivers subject to certain conditions. India also entered into project-specific agreements with other neighbours like Nepal and Bhutan, but these essentially do not constitute sharing arrangements. The more recent Treaty on Ganga waters with Bangladesh (1996) prescribes a formula for sharing the lean season flows of the river at Farakka between the months of January and May every year. It also envisages similar agreements or understandings with regard to other common rivers.

The optimised and integrated development of South Asian and trans-Himalayan river waters calls for cooperation amongst the countries, including data sharing. The Ganga Treaty with Bangladesh and the Mahakali Treaty with Nepal use expressions such as no harm, equal entitlement, good neighbourliness, optimum utilisation, integrated development, mutual benefit and so on, all of which have cross-border implications

The important water-related issues with regard to each of our neighbours are discussed below:

BANGLADESH: Issues of sharing the Ganga, Brahmaputra, Meghna and 51 other common rivers have been in contention between the two countries over the past half-century. Actual sharing of the lean flows of the Ganga became problematic in 1975 with the commissioning of the Farakka Barrage. A series of agreements were put in place until 1988. Thereafter, relations soured on this issue until a breakthrough was achieved with the signing of the Ganga Waters Treaty in December, 1996.

The Treaty stipulates an "emergency" situation when discharges fall below 50,000 cusecs, necessitating an immediate dialogue between the two countries to decide on sharing arrangements; and calls on both sides to cooperate in finding a solution to the long term augmentation of the lean season arrivals at Farakka and conclude water sharing agreements with regard to other common rivers. It also enjoins India to endeavour "to protect (lean season) flows of water at Farakka as in the 40 years (1949-88) average availability" as set out in an indicative Schedule II. These are now international obligations. Any Indian use and diversion upstream, including groundwater extraction would have to keep this in mind.

Indicative Schedule for Sharing Ganga Waters at Farakka
(Annexure – II of the Treaty)

If actual availability corresponds to average flows of the period 1949 to 1988, the implication of the formula in Annex-I for the share of each side is :

Period	Average of total flow 1949-88 (cusecs)	India's share (cusecs)	Bangladesh's share (cusecs)
Jan			
1-10	1,07,516	40,000	67,516
11-20	97,673	40,000	57,673
21-31	90,154	40,000	50,154
Feb			
1-10	86,323	40,000	46,323
11-20	82,859	40,000	42,859
21-28	79,106	40,000	39,106
March			
1-10	74,419	39,419	35,000
11-20	68,931	33,931	35,000 *
21-31	64,688	35,000*	29,688
April			
1-10	63,180	28,180	35,000 *
11-20	62,633	35,000 *	27,633
21-30	60,992	25,992	35,000 *
May			
1-10	67,351	35,000 *	32,351
11-20	73,590	38,590	35,000
21-31	81,854	40,000	41,854

(* Three ten day periods during which 35,000 cusecs shall be provided)

Both India and Bangladesh have Teesta Barrages on either side of the border and plan to irrigate extensive commands whose full requirements cannot be met without lean season augmentation or integrated use of the waters of rivers adjoining the Teesta within the Brahmaputra system. Meanwhile, the discharge data of the Teesta must be reconciled before even *ad hoc* allocations of its flows can be made. These issues are being addressed by the two Governments through the Indo-Bangladesh Joint Rivers Commission.

Augmentation of the lean season flows of the Ganga can be secured by local rain water harvesting, conservation, and demand management through incremental steps over a period of time. But additionality can only come through storing the monsoon flows, especially in the Nepal Himalaya or through transfer from the Brahmaputra system. The Sapta Kosi High Dam offers the best prospect of augmentation and this possibility will need to be kept in mind when the design and operational parameters of the project are decided. Bangladesh would need to be brought into the picture at some stage, sooner or later, whether directly or indirectly. Bangladesh is aware that it will have to share the capital costs of the projects to the extent of benefits received.

A lesser quantum of augmentation may be possible from other major storages and through groundwater recharge, and through exploitation of deep aquifers if their techno- economic parameters are established to be favourable.

Calcutta Port studies should be undertaken with respect to its long term flushing requirements in relation to alternatives such as new ports and inter-modal transport with a strong inland water navigation component.

Augmentation of Teesta and Ganga flows could also come through possible storages on the Dharla, Dudhkumar, Sankosh and Manas in Bhutan. A large hydel storage on the Sankosh has been investigated, while a Manas-Sankosh-Teesta-Mahananda-Ganga link has been studied.

The Brahmaputra alone carries about 30 per cent of India's total annual runoff and has an average annual discharge greatly in excess of the corresponding figure for any other river in the sub-continent, whether expressed in terms of per capita availability or per unit of culturable area within its basin. This mighty river, which is virtually untapped, is, therefore, an obvious potential source for transferring supplies for supplementation elsewhere. The 1977 and updated 1983 Indian proposals envisaged large storages on the Dihang and Subansiri with a mega Brahmaputra-Ganga gravity Link canal, taking off from a barrage at Jogighopa and traversing part of lower Assam, northern Bangladesh and West Bengal. The proposals could not make headway in the face of objections by Bangladesh.

Alternatives exist. A barrage at Jogighopa could divert water by lift to the Ganga *via* the Teesta and Mahananda canals. If necessary, they could feed a number of other rivers flowing into Bangladesh such as the Karatoya and Atrai *en route*. These could subsume the irrigation and other requirements of Bangladesh in respect of some of the other common rivers as well. Indeed, this would enable Bangladesh to command areas which it otherwise could not on its own, with fishery and navigation benefits as well to some extent.

Bangladesh, however, argues that even the existing virgin lean flow of the Brahmaputra (not less than 1,20,000 cusecs) is insufficient or only just sufficient to maintain the ecological health of the lower Brahmaputra-Meghna basin and prevent salinity ingress. These fears are obviously exaggerated and will be more than met in the long run if storages on the Dihang, Subansiri and other major tributaries materialise in Arunachal as anticipated. Larger dry season flows in the Brahmaputra will also enhance the efficiency of the inland waterway from Dhubri to Calcutta.

Various potential alignments for water transfers from the Brahmaputra have been proposed, some limited to Bangladesh, but others extending into India either through Bangladesh or through the Siliguri neck.

Obviously, careful techno-economic planning and environmental care will be necessary. But optimisation, mutual benefit and integrated development of the system will require bilateral and regional cooperation.

Likewise, the problem of several other common rivers in the Cachar-Tripura sector can be subsumed in the Tipaimukh benefit area if the dam on the Barak and the associated irrigation barrage at Fulertal is taken up. It is interesting to recall that the Tipaimukh project was conceptualised in 1972-73 by the Indo-Bangladesh Joint Rivers Commission (JRC) in response to Bangladesh's quest for a solution to floods in the Sylhet-Dhaka plains.

Bangladesh has reason to be interested in what could be a mutually beneficial project with multiple irrigation, flood moderation, navigation and energy dividends. It has apprehensions of possible drainage and flood problems in the Sylhet bowl from enhanced dry season flows passing through the turbines. These fears need to be assuaged and techno-economic costs and benefits assessed. Such a study was agreed upon in the JRC and should be vigorously pursued. But, before this project is taken up for implementation, certain inter-state problems within India will have to be resolved.

Other Indo-Bangladesh issues pertain to water quality, shifting course of boundary rivers, impact of anti erosion measures, exchange of hydrological and flood discharge data in real time and the tying up of flood embankments on common rivers.

NEPAL: Hydro-power could be for Nepal what oil is to the Gulf. However, its currently assessed techno-economic potential of 42,000 MW needs a market which primarily lies in India. This complementarity apart, India would benefit by storages in Nepal to moderate floods and expand irrigation in the Uttar Pradesh and Bihar plains.

Earlier diversion schemes on the Sarada (Mahakali), Kosi and Gandak notwithstanding, Indo-Nepal water resource development for regional benefit has made limited progress on account of a variety of misperceptions and misgivings on both sides. The landmark Mahakali Treaty of 1996 hopefully heralds a new beginning. It is a good example of bilateral cooperation in joint water resource development. Both Parties agree "that they have equal entitlement in the utilisation of the waters of the Mahakali River without prejudice to their respective existing consumptive uses......". Entitlement is not the same as ownership of naturally flowing water. Likewise, protection of existing uses or prior appropriation cannot result in expropriation of the reasonable and equitable rights of late starters.

The Mahakali Treaty stipulates that the cost of the project shall be borne by the parties "in proportion to the benefits accruing to them". The power, irrigation, flood control and other benefits accruing to the parties "shall be assessed". The letters exchanged with the Treaty provide that "net power benefit shall be assessed on the basis of, inter alia, savings in costs to the beneficiaries as compared with the relevant alternatives available" ; irrigation benefits "on the basis of incremental and additional benefits due to augmentation of river flow" ; and flood control "on the basis of the value of works saved and damages avoided". But this "precludes the claim in any form by either Party on the unutilised portion of the shares of the waters of the Mahakali River of that Party....".

A dispute resolution mechanism provides for binding arbitration by a three-member tribunal the Chairman of which may, in the absence of mutual agreement between the parties, be appointed by the Secretary- General of the Permanent Court of Arbitration at the Hague.

The Treaty enjoins India to ensure a flow of not less than 10 cumecs (350 cusecs) downstream of the Sarada barrage "to maintain and preserve the river eco-system". Further, it provides that the water requirements of Nepal "shall be given prime consideration in the utilisation of the waters of the Mahakali river".

The cost-benefit assessment and sharing principle is repeated verbatim in the understanding reached by Indo-Nepalese experts on the Sapta Kosi project. The earlier Kosi and Gandak Agreements also stipulated certain conditions with regard to Nepalese uses, local inter-basin transfers and navigation. The latest Indo-Nepal understanding on the Sapta Kosi commits India to making a feasibility study for providing a navigation link either by river or a canal from Chatra to the confluence of the Kosi with the Ganga in Bihar.

Flood forecasting and hydrological and other relevant data exchange represents another important area of cooperation which must be strengthened between Nepal and India. It is encouraging to note that there is some agreement for sharing hydrometeorological data. Nepal and India have also agreed to upgrade and modernise the network and also increase the density and coverage of stations which will help better assessment and utilisation of water resources. 25 rainfall and 20 river gauge stations are being set up in Nepal with partial Indian assistance, wherefrom real time data will be transmitted to India. Similarly, India will supply data from its stations to Nepal on a reciprocal basis.

***BHUTAN*:** Several significant right bank tributaries of the Brahmaputra enter India from Bhutan. There are no water resource problems between the two countries. In fact, there has been growing cooperation over the years. The Chukha project (370 MW) is a model of cooperation and currently yields Bhutan an annual revenue over Rs. 120 crores from the sale of power to India. Other projects are under construction (Tala – 1,050 MW and Kurichu - 60 MW) and investigation (Sankosh-4,025 MW), through joint collaboration, with full Indian funding.The existing modest Indo-Bhutanese grid link constitutes the first step towards the creation of what in time could hopefully become a South Asian Power grid.There is a regular hydrometeorological data exchange with Bhutan through a network of stations established by India in Bhutan, but operated by Bhutanese officials under the overall guidance of an Indian expert.

***CHINA*:** There are no subsisting agreements between China and India pertaining to water resources. The Chinese used to communicate discharge data in relation to the Yarlungzangbo (Upper Brahmaputra) until 1962, when this transmission ended with the Sino-Indian border conflict.

There are only a few water resource projects in the Upper Brahmaputra and, possibly, Arun basin in Tibet and no reports are available of anything done in the upper Gandak, Sutlej or Indus basins therein. The terrain, limited culturable area and population and modest industrial development in Tibet have thus far helped to prevent any problem of reduced stream flows or water quality.

The "Scientific American" of June, 1996 reported Chinese engineers telling the Chinese Academy of Engineering Physics in December, 1995 that the waters of the Upper Brahmaputra could be diverted into the arid Northwest region and Gobi desert through nuclear explosives. The techno-economic viability of any such endeavour may be questioned.

The possibility of diverting water from the Yarlungzangbo to the Upper Arun or Gandaki has also been mooted. Still futuristic, but more plausible, is the dream of harnessing the immense potential of the Brahmaputra as it makes a giant U-bend from Tibet to Arunachal and Assam, dropping almost 2,438 m (8,000 feet) in the process. Japan's Electric Power Development Corporation did a desk-top study of a possible upper Brahmaputra cascade with a regulating dam south of Lhasa and a series of power stations below that, crowned by two alternative Tibet-to-Assam power tunnel projects with an installed capacity of 48,000 to 54,000 MW at one or other of these two sites alone.

It is significant that such ideas are extant.

MYANMAR: A number of small streams rising in eastern Manipur drain into the Kubaw Valley and, like the larger Imphal/Manipur river, flow into Myanmar to drain into the Chindwin which falls into the Irrawaddy. India has some small irrigation uses on the Manipur river within Manipur and has developed the Loktak Hydro Project (105 MW) and is proposing to utilise its tail race waters in the Lower Loktak hydro scheme. There appears to be little likelihood of any conflict of interest with Myanmar here.

There is also scope for Indo-Myanmarese cooperation in jointly developing the hydro potential of the Chindwin to mutual benefit.

The Chhimtuipui River (otherwise known as the Kaladan or Kolodyne) rises in Myanmar, then marks the Indo-Myanmar border for quite some distance before entering southern Mizoram and then finally re-entering Myanmar to empty into the sea near Sitwe (Akyab). The river is navigable in Myanmar from Paletwa, some 100 kms from the tip of Mizoram, to the sea. A lower Chhimtuipui hydro project is under investigation in Mizoram, and the state administration would be interested if drafts could be enhanced by this project or otherwise to give it and even adjacent areas in Northeast India a direct outlet to the sea in the future.

PAKISTAN: The Partition of India divided the Indus basin system as well as the intricate network of canals within it. A major dispute on sharing of waters arose thereafter. Mediatory efforts by the World Bank resulted in the signing of Indus Waters Treaty, 1960. Allowing for a transitional period of a decade within which certain replacement works were to be completed, the Treaty apportioned the entire waters of the three Eastern Rivers, the Sutlej, Beas and Ravi to India, except for some very limited domestic, non-consumptive and irrigation use by Pakistan for 45,500 acres of annual cultivation. The waters of the three Western Rivers, namely the Indus, Chenab and Jhelum, were in turn allocated to Pakistan, less certain uses by India.

The Treaty has worked satisfactorily, despite strained Indo-Pakistan relations and two wars, and the mechanism of the two Indus Commissioners has functioned fairly smoothly.

There is no quantitative limit on Indian uses from the Western rivers for domestic and industrial purposes in J&K. The relevant provision entitles the Government of India and the State Government to formulate appropriate schemes of rural and urban water supply in J&K. Non-consumptive uses are permitted in J&K for purposes of timber floating, navigation, flood protection, fisheries and wild life, and similar beneficial uses provided that the water is returned to these rivers exclusive of seepage or evaporation incidental to the drawal or use. However, the procedures involved have proved to be cumbersome and, sometimes, unproductive.

As of April 1, 1960, India was irrigating 42,179 acres from the Indus, 5,17,909 acres from the Jhelum and 82,389 acres from the Chenab. These uses were permitted to continue apart from some restricted withdrawals from the Chenab Main through the Ranbir and Pratap canals for agriculture use. Additionally, India was permitted to develop further irrigation and make withdrawals from the Western Rivers to the extent considered necessary by it but within limits so as to satisfy the requirements of the irrigated cropped area prescribed in Annexure C of the Treaty. Taken as a whole, the Treaty allows India to irrigate 1.34 millions acres from the three Western Rivers as against which only some 0.81 million acres or about 60 percent of the permissible limit has been brought under irrigation to date.

Further, the permissible irrigable acreage may be redistributed among the three Western River drainage basins in such manner as may be agreed upon between the Indus Commissioners of India and Pakistan. Nor is there any bar on changing the cropping pattern to optimise agricultural production. This opportunity needs to be exploited.

The Indus Treaty enables India to build storages on the three Western Rivers to the extent of 0.40 MAF on the Indus, 1.50 MAF on the Jhelum (excluding the Jhelum Main), 0.60 MAF on the Chenab Main, and 1.10 MAF on the Chenab (excluding the Chenab Main). This total permissible storage of 3.60 MAF on the three Western Rivers by India is further broken down purpose-wise into 1.60 MAF for power, 0.75 MAF for flood cushioning, and 1.25 MAF for general storage which may also be used for hydroelectric power generation and other purposes. India has thus far not constructed conservation storages on any of the three Western Rivers. These rivers have an assessed hydro potential of 8,825 MW at 60 percent load factor. But as of now only about 1,350 MW has been harnessed, most of it on the Jhelum and Chenab and only 4 MW on the Indus.

The Tulbul Navigation Project on the Jhelum in J&K was taken up in 1984, but construction has since been held up. Pakistan insists that it is a storage work and not permitted under the Indus Waters Treaty. According to India, no impoundment is involved as only a control structure to regulate the natural storage of the Wular lake has been provided to improve the navigable draft in the river after the floods during the winter season. Incidentally, the project would improve the power output of all the hydro-electric projects downstream in India and Pakistan.

This recapitulation suggests that India should fully utilise the permissible pondage/storage for hydro-electric development and for achieving the prescribed irrigated cropped area at the earliest. Having done this, consideration can be given to harnessing the remaining unutilised potential. Necessary modifications may have to be made in the Indus Waters Treaty for this purpose. This would be in the mutual interest of both countries but detailed studies should precede any formal approach to Pakistan whenever appropriate.

India has been allocated the waters of the three Eastern Rivers on which certain projects have been executed and some others are planned. The flows below the rim stations criss-cross the international boundary before finally entering Pakistan. Mutual cooperation with that country may still be required for fruitful and economical utilisation of this residual flow in an optimised manner. Such an effort may be considered later, as and when situation permits.

There is also a drainage problem in the Bhakra-Pong and Indira Gandhi Nahar Project (IGNP) commands in Punjab, Haryana and Rajasthan which has given rise to problems of salinity and waterlogging. Pakistan faces similar problems. Both countries have developed tubewell grids to provide vertical drainage through conjunctive use. The salinity problem, however, remains and to overcome this, Pakistan has undertaken the construction of a 300-km long Left Bank Outfall Drain to the sea from Nawabshah where a network of subsidiary drains converge.

The IGNP command in Rajasthan slopes northeast to southwest towards Sind. India is enjoined by Article IV (10) of the Indus Treaty not to permit pollution of stream flows into Pakistan beyond acceptable limits. This precludes leading drains into Sutlej as it leaves this country. The satisfactory disposal of saline water from the IGNP command, therefore, requires detailed study. One of the solutions, perhaps, would lie in negotiating with Pakistan, for an outlet to its Left Bank Outfall Drain or other systems in Sind on the basis of a suitable *quid pro quo*.

11.3 Inland Navigation

The Ganga-Brahmaputra-Meghna river system once constituted a bustling artery of commerce. The Partition of 1947 divided the waterway across new international boundaries as a result of which Inland Water Transport (IWT) declined and traffic moved to the railways and the road. The energy-efficient, environmentally-friendly and land-saving attributes of IWT have reawakened interest in inland navigation at a time, when South Asian cooperation has also taken a positive turn.

The Inland Waterways Authority of India (IWAI) is developing National Waterway No. 1 on the Ganga from Haldia to Allahabad through the Farakka lock, and National Waterway No.2 along the Brahmaputra from Dhubri to Sadiya. Further inter-connection would lie through the Sunderbans and Bangladesh, unless the Jangipur lock at the outfall of the Bhagirathi on the Ganga is also rendered operational as would be desirable. This will not be possible without a new IWT protocol with Bangladesh, specifying this route.

An Indo-Bangladesh Inland Water Protocol exists and has been recently extended. The Protocol licences transit along two routes up the Brahmaputra from Haldia to Dhubri and up the Meghna-Barak from Haldia to Karimganj towards which India pays Bangladesh Rs. 1.8 crores annually for channel maintenance. Navigable channels should have a minimum depth of two metres and a width of 45 metres.

India would find it useful to negotiate additional transit routes through Bangladesh including some inter-modal routes. Other new routes could be a link from Demagiri in Mizoram to Chittagong down the Karnafuli river which used to be a traditional outlet. A lock or cargo-transfer arrangement will need to be made around the Kaptai dam in the Chittagong Hill Tracts and the Karnafuli developed into a navigable fairway. This would be greatly beneficial. Another route could be created by developing the Feni river from southern Tripura to the sea for inland navigation. A third proposal under discussion with Government of Myanmar is for developing navigation through the Kaladan/Chhimtuipui river to connect southern Mizoram to the sea at Sitwe (Akyab). In all of these, political and investment cost-benefit considerations will prevail.

Nepal has long been interested in an outlet to the sea and has presently pinned its hopes on a Sapta Kosi-Ganga canal which is to be investigated. Rail India Technical and Economic Services (RITES) reportedly did a feasibility study for Nepal a couple of years ago on possible inland navigation on the Gandak. Under the Indo-Nepal Agreement on the Gandak (1959), a small navigation lock was constructed upstream of the barrage. It has, however, not been in operation due to siltation and inadequacy of lean flows. Unless storages are built upstream in Nepal to augment the lean season flow, no navigation in the Gandak will be feasible. Therefore, of all the available options, the Kosi navigation link appears the most viable, if at all. In September, 1996, both Governments agreed to carry out a joint study on navigational possibilities in the Ghagra, Gandak and Kosi rivers. This study should be instituted at the earliest.

11.4 Flood Management

Flood moderation and forecasting is a matter of common concern and the need for improving hydrological and silt data and transmission in real time has been discussed in preceding sections. Likewise, flood embankments need to be tied together across national boundaries. There has to be agreement on construction of anti-erosion and flood protection works along common or successive rivers so that one country's solution does not cause problems to the other. Consultation and coordination are necessary.

There are flood problems in the Nepalese terai and adjacent areas in India, many of which could be satisfactorily overcome by cooperation between Nepal and India. Flood forecasting and warning is another area for mutual cooperation. Significant flood moderation over a large part of the Himalayan Ganga basin is not possible in Indian territory as suitable storage sites are not available. However, such sites are available in Nepal.

Similarly, in the Brahmaputra storage sites are available. In the Barak/Meghna, a suitable site at Tipaimukh for a major dam has been identified. At one time, after devastating floods in 1987 and 1988, Bangladesh took the view that it could find a self-contained solution to its flood problems. This marked the beginning of its Flood Action Plan with foreign and multilateral assistance which appears to have faltered on technical and environmental considerations. Bangladesh appears to have shown a revival of interest in storages in India, Nepal and Bhutan for augmentation and in watershed management to mitigate sedimentation. Tipaimukh, the Dihang and Subansiri Projects, now being re-worked as cascades, and the Sapta Kosi dam are among the more promising projects. Bangladesh's concerns need to be taken into account in planning and designing these projects in order to secure multipurpose benefits including flood control and moderation.

11.5 Integrated Energy Systems

The GBM and Indus basins are endowed with a huge hydro potential which has only been harnessed to a very limited extent. This power can be traded across frontiers through power exchanges as hitherto or, more meaningfully, through an interconnected grid. Chukha power exports to India represent only a beginning. Transmission lines are being strengthened with extra high voltage systems coming into place. It is now established that substantial blocks of Northeastern power can be safely transmitted to the eastern grid through the Siliguri corridor. Yet in certain circumstances it would probably be cheaper to transmit Northeast power to the Indian heartland *via* Bangladesh, making sales to that country *en route*. Bangladesh itself seems poised to make large gas discoveries in which case an integrated energy grid could be contemplated and Bangladesh gas traded for Indian hydro power.

Dam construction has certain environmental costs, but hydel power is cleaner than any other and enjoys a degree of reliability and flexibility, especially for peaking, that gives it a premium quality. However, new controversies are emerging about methane discharge from storage reservoirs. These need examination.

The Indian regional grids are steadily getting linked and a national grid should emerge within a decade, with systems being synchronised and run in parallel. The Asian Development Bank (ADB) has funded a study of two sets of power links between Bangladesh and India. These developments require to be well planned instead of being taken up in a piecemeal and *ad hoc* fashion and some machinery for forward regional planning and joint consultation would be necessary.

11.6 Environmental Management

Water resource development will increasingly run into environmental opposition, nationally and internationally. The experience of Tehri, Sardar Sarovar, Tipaimukh, Arun-3 (in another context), Kaptai and the proposed Kalabagh dam in Pakistan are illustrative.

The issues relate to impacts both above and below the dam and in the command areas, estuaries and deltas; forest and possible bio-diversity loss; displacement and disruption of social networks; impacts on wild life and fisheries; health impacts; cultural loss; and dam safety linked to seismicity and debris or glacial lake outbursts. Minimum flows are necessary for in-stream uses like fisheries and navigation and to maintain the ecological health of the river, including prevention of salinity intrusion, and sustenance of mangroves and of the coastal environment generally. Several mitigative packages have been developed. All these factors and impacts need to be studied with care and compassion. Not all of them have trans-boundary impacts. Some do. Transparency is important in all these studies.

Water quality is becoming increasingly important with greater abstraction leading to such problems as arsenic contamination and salinity ingress. Again, not all these problems emanate from cross-boundary interventions. Pollution is becoming a very sensitive issue with industrialisation and the increasing use of fertilisers and pesticides. Cross-border water monitoring and establishment of common regional standards as in many other matters, would be very useful.

The threat of global warming and climate change has engendered new concerns. Some earlier critics are beginning to look on hydro power with a kindlier eye as clean renewable hydro-electric energy can substitute dirty coal and other fossil fuels, quite apart from saving forest cover which might otherwise be felled for fuelwood. The Kyoto Conference on Global Climate Change in December,1997 elaborated new ideas concerning emissions trading and joint implementation mechanisms. These were further discussed at the Buenos Aires round in December,1998 with the United States insisting on imposing emission cuts on developing countries as well, particularly India and China, both large and growing coal users.

The point to study and concert action in South Asia is the extent to which emissions trading can be used to generate funds for clean Himalayan hydro power and in negotiating the fine print so that the terms are right.

11.7 Private Investment

Water resource development in all sectors is being increasingly thrown open to private investment through build-own-operate-and-transfer systems in a variety of combinations. The Indo-Nepal Power Trade Agreement, 1996 opens the door for private investment in power development in Nepal and the sale of energy in India or Bangladesh or elsewhere, whether to governments, Central or State, electricity boards, or corporate consumers. Foreign and Indian investors have shown interest in engaging in hydro development in this country and in Nepal. This would raise several issues and calls for the evolution of a clear policy framework.

The problem has already surfaced in the West Seti project in Nepal (750 MW), for which a foreign company has signed an agreement and is negotiating power sales in India. The Nepalese Government is meanwhile concerned that the augmented stream flows in consequence, which reach India through the Karnali, should not be a gift but should bear a price tag if they find beneficial use. Another foreign company, which is talking to Nepal on the Karnali Project, has also been confronted with the question of downstream benefits and guarantees on the amortisation as the power and water markets both lie in India.

The effects of regulation of major dams to be built through private investment in Nepal and Bhutan and their safety would need to be examined at an early stage of negotiations in order to prevent adverse effects, if any, in India.

There could be other issues, such as that of counter-guarantees. All these merit study. Expertise has to be developed both with regard to techno-economical aspects and negotiating skills.

11.8 Role of Non-Governmental Organisations

Emerging water shortages and deteriorating water quality as well as larger environmental and resettlement and rehabilitation (R&R) issues have made water resource development a focus of Non-Governmental Organisations (NGO) and community attention. In India, there have been parallel processes of Track II efforts to engage opinion leaders, parliamentarians, professionals and the media in the matter of conflict resolution with regard to water issues between India, Nepal and Bangladesh in particular. These have been useful and are continuing.

Environmental activists, both domestic and regional /international, have also been vocal in the matter of environmental impacts and displacement. This international dimension of even a purely domestic project was painfully evident in the matter of World Bank and Japanese funding for aspects of the Sardar Sarovar Project. Large inter-basin transfer projects between countries of the GBM region will very likely attract international attention, triggered primarily by local objections on a variety of counts. Sound and careful project design and evaluation with built-in measures to mitigate or adequately compensate for adverse environmental, social and cultural impacts is in any event becoming mandatory. As already emphasised by us, transparency, public awareness and stakeholder participation are the pathways to future water resource development. This will be more so in respect of trans-boundary projects as also to combat the rise of hydro-politics. Political will is sure to be strengthened by genuinely consensual approaches.

11.9 Institutional Mechanisms and Capacity Building

India has thus far favoured bilateral negotiations in developing regional water resources. The Indus agreement was brokered by the World Bank but this is not a model India may wish to repeat. Nor has it favoured trilateral discussions with Nepal and Bangladesh although the Joint Committee of Experts consisting of the Indian and Bangladesh Water Resource Secretaries did in 1987 make a joint approach to Nepal with regard to Bangladesh's proposal for augmentation of the Ganga below Farakka. The Nepalese were not interested unless a clear benefit for them was indicated. India's water relations with Bhutan have been entirely bilateral. Suggestions for basinwide studies as a part of regional cooperation have also been spurned on the ground of practicality and avoiding complexities inherent even in bilateral negotiations being further complicated by third party intervention.

The broad pattern has been to set up overall or project specific bilateral bodies. Thus, the Indo-Bangladesh Joint Rivers Commission has a wide charter embracing all rivers. In the Indo-Nepal context, specific mechanisms were set up under the Kosi and Gandak agreements. These have fallen into disuse. A Karnali Committee was set up. There have also been ministerial and secretary level committees to oversee and debottleneck. These arrangements have worked with modest success but need to be used more purposefully.

A Joint Committee of Experts is currently dedicated to preparing a joint detailed project report (DPR) for the Sapta Kosi-cum Kurule/Kamala Diversion Project. The Mahakali Treaty envisages a Mahakali Commission and a Pancheshwar Development Authority. The Indus Commissioners deal with all Indo-Pakistan water issues. Specific project authorities are engaged in the management of the Chukha and Tala projects in Bhutan.

The logic of individual project cooperation may network over time into larger integrated basin or trilateral structures. There is also utility in strengthening certain existing mechanisms such as the JRC by giving it a permanent secretariat and some funds. There would certainly appear to be a strong case for designating certain bodies like, say, the National Water Development Agency (NWDA) in India, the Water Resources Planning Organisation (WARPO) in Bangladesh, and the Standing Committee of the National Water Council or the Energy Development Authority in Nepal to interact and build up a data bank and clearing house of information. All these agencies are engaged in broadly similar national tasks of long term water resource planning and development and prioritisation. The time has come to exchange national basin plans for long term water resource planning and development through a regional forum. This could facilitate regional optimisation reflecting the highest common denominator of these national plans .

Capacity building for regional water resource development is also necessary. Data gaps need to be plugged; manpower development is essential; and equipment development will entail savings in import costs. These are important. The emphasis should be on maximising local manpower, material and equipment, then going to the regional level and only thereafter, going international in order to save heavy foreign exchange outgoes and to build national and regional self-reliance. We believe that this should be the strategy of development. It will not happen by itself and calls for studied, collaborative thinking and action.

In the matter of capacity building, the role of universities, research insitutions and NGOs has to be adequately recognised and promoted. Quite often, international water resource issues tend to be politicised and get warped in the process . It is essential that the scientific as well as the techno-socio-economic aspects of these issues are not allowed to be obscured by parochial considerations. Towards this end, Track-II efforts should be mounted and sustained by nurturing and strengthening suitable institutions which can also play a role in the creation of public awareness about international water resource issues.

11.10 Planning Needs

The time frame within which projects on the international rivers will materialise is uncertain and will in any event take up to two to three decades. Our planning should, therefore, proceed on the basis of varied scenarios.

It would be useful to study appropriate management structures for joint venture projects in Nepal and Bhutan. Further, it would be desirable for India to post a WRD/Energy Attache to our Embassies in Kathmandu – with a watching brief extending to Bhutan – and Dhaka. Bihar already has a Kosi Liaison Officer in Kathmandu.

There is need to harness Himalayan dam and barrage design and construction skills and consultancy expertise for use in Bangladesh and Nepal/Bhutan through joint ventures or in contracts through international bids. Agencies like the Bhakra-Beas Management Board (BBMB), Tehri Hydro-Development Corporation (THDC) and Power Grid Corporation, should be encouraged to explore such a continuing role. Bharat Heavy Electricals Ltd. (BHEL) and other equipment manufacturers should enter bids for contracts in Nepal and Bangladesh and organise training programmes for operatives from these countries.

The Government of India should consider setting up, say, a Rs. 1,000 crore revolving fund to extend suppliers credit for Indian equipment and material to support water resource development in Nepal/Bhutan and elsewhere.

We should initiate studies for a South Asian power grid and a wider energy grid for hydropower, coal, nuclear power, oil and gas. There is need to restore the GBM river system as a unified inland-cum-coastal waterway and encourage public and private carriers to develop and operate barge and coastal fleets with inter-modal/transhipment linkages. This will require a legal framework and agreed documents, customs procedures, bonded warehousing etc.

11.11 General Observations

The issues brought out in the preceding paragraphs are but some of the international and/or regional and bilateral dimensions of integrated water resource planning and development in India. There could be others too. Other nations have grappled with similar problems or are beginning to confront them. There is much that can usefully be learnt from national and international bodies that would be willing to share their experience. It would be prudent to tap these sources. The largest part of India's water lies in its international river basins. These should be fully and optimally developed at the earliest. While doing so in the service of large water-stressed areas in other basins, due consideration must be given to the international aspects of water resource development so as to avoid controversies, especially in view of looming water shortages and water quality issues.

All these possibilities and issues call for the early completion of requisite studies in order to facilitate informed consideration and decision making. The Commission's Working Group on the International Dimensions of Water Planning in their Report, has suggested a detailed Action Plan in this regard.

In an era of emerging water shortages, we cannot but look beyond our frontiers in planning for India's water future. The Himalayan rivers are shared to a very large extent and there is a hydrological unity in them. Ignoring these ground realities can only result in warped national planning that falls short of optimisation and maximisation of benefits. Regional cooperation in water and energy development offers solutions to many national problems and will speed up both national and regional development, with a strong bonding of good neighbourliness and interdependence among the countries for mutual benefit.

CHAPTER -12

WATER QUALITY AND ENVIRONMENTAL ASPECTS

Development has significant effects on environment. Yet, modern economic development took place until the middle of the century as if such effects did not matter and that Nature's ability to withstand the changes was limitless. It was only a few decades ago that it was realised that the pristine forests and biodiversity of the earth were disappearing fast and that quality of soil, water and air was deteriorating. It was recognised that the changes were of such magnitude that development itself was becoming unsustainable and that human well being, which was the object of development, was getting jeopardised. The need to avoid the adverse environmental effects of development and to incorporate the environmental dimensions in the strategies and programmes of development became urgent and imperative.

As part of modern economic development, water resources development has also got far reaching ecological consequences. Some of them are undoubtedly beneficial to human health and well being. Others threaten the natural resource base and its environment and the long term productivity of the water projects themselves. Apart from deforestation and loss of habitat for plants and animals, they cover the entire range of environmental components. The challenge in water resource development is to balance the needs of development and those of environmental health and thereby ensure the sustainability of development. Integrated management of water resources should be based on the perception of water as an integral part of the ecosystem and as a natural resource whose quantity and quality determine the nature of its utilisation. Water use, in turn, has its impact on water quality and, therefore, utilisation of water has to be so managed as not to contribute to the deterioration of water quality.

In this chapter, we consider these issues in some depth along with a focus on the environmental impact of large water resource projects and on water quality, the steps that are being taken during the last few years to deal with them and further action that is necessary.

12.1 Overview

Global attention to environmental problems was drawn by the United Nations Conference on Environment at Stockholm in 1972. Since then and following the establishment of the United Nations Environment Programme (UNEP), the international organisations like UNDP, UNICEF, FAO and WHO have engaged themselves in programmes of environmental improvement and in spreading awareness of the relationship between development and environment and the need to take measures to reduce the adverse environmental impact of development. Many international conferences have been held , which have drawn attention to various aspects of the problem and suggested policies and action programmes for adoption by countires. International development finance agencies like the World Bank, which were concerned earlier mostly with economic returns from projects, have shifted focus to social and environmental issues during the last few years. Some observers feel that the pendulum has swung from one extreme to the other and that, while projects in developing countires are stalled on environmental considerations, the larger issues of damage to global environment by the advanced , industrialised countires are not being addressed. Be that as it may, it is in the interest of developing countries themselves to avoid the future high costs of restoration and, build into development efforts, environmental concerns from the very beginning.

In India, interest in environmental issues began at the national level early in 1970s. Observers and scholars were drawing attention to the denudation of forests in the Himalayan and other mountains and to the adverse effects of soil erosion in different parts of the country. To arrest the rapid fall in forest cover that was taking place, action was necessary at the national level, but 'forest' was a state subject under the Constitution of India and there was no mention of 'environment' in it. Starting with the shifting of 'forests' to the concurrent list and the inclusion of provisions in the Constitution of India regarding 'environment' in the Directive Principles of state policy and Fundamental Duties, in 1976, a series of laws were enacted and policies and programmes were initiated during the next ten years.

Article 48 A of the Constitution dealing with the Directive Principles of state policy lays down that " The State shall endeavour to protect and improve environment and to safeguard the forests and wildlife of the country".

Article 51 A(g) of the Constitution dealing with Fundamental Duties states that "it shall be the duty of every citizen of India to protect and improve the natural environment, including forests, lakes, rivers and wildlife and to have compassion for living creatures".

The Eleventh Schedule of the Constitution lists soil conservation, water management, watershed development, social and farm forestry, drinking water, fuel and fodder, non-conventional energy sources and maintenance of community assets in which specific functions should be devolved by state governments to panchayats. All these are varied aspects of environmental protection.

The Twelfth Schedule of the Constitution lists wildlife, protection of environment and protection of ecological aspects in relation to water, sanitation and solid waste management, parks and gardens as subject areas in which specific functions should be devolved by state governments to urban local bodies.

As regards laws, starting with the Forest (Conservation) Act in 1981, a series of laws have been enacted of which the Environment (Protection) Act, 1986 and those on water and air pollution are more important. The Environment (Protection) Act defines 'environment' as " one, which includes water, air and land, the inter-relationships which exist among and between water, air and land and human beings, other living creatures, plants and micro-organisms". Water pollution has been defined as "any man-made alteration of chemical, physical or biological quality of water, which results in unacceptable depreciation of the quality or environmental value of water" .

Supported by such legislation, over the years, new environmental policies, regulations and guidelines have been brought into effect along with institutions.

Public Interest Litigation is one of the important means through which concerned persons and organisations as well as activists have raised environmental aspects of development projects before the High Courts and Supreme Court of India. Through their judgements in a number of cases, the Supreme Court has given several directions for ensuring environmental protection while sanctioning and implementing development projects.

Because of the significant environmental impact of water projects, many of these directions apply to them. Taken along with the regulations and guidelines, they in turn, have profound effect on the model, character, details and speed of implementation of water projects. They relate mainly to the following :

- Integrated development of water resources through a holistic approach.
- Protection of water resources, water quality and aquatic water systems.
- Pollution of surface and ground water to be controlled under existing laws on environment.
- Minimum flow of water in major rivers.
- Environmental impact to be studied and assessed before a project is taken up and remedial measures proposed.
- Implementation of remedial measures *parri passu* with implementation.
- Resettlement and Rehabilitation of displaced people to be an integral part of the project.
- The "Polluter Pays" principle to be applied in all cases of water resources development.

12.2 Environmental Impacts of Water Projects

As stated earlier, water projects have both beneficial and detrimental effects. The more important beneficial effects are:

Domestic and Industrial Water Supply : One of the important roles played by water resources projects is to provide domestic and industrial requirements with a higher degree of reliability. Many of the cities, towns and villages are dependent upon supplies from various water resources projects. The drinking water requirements of Delhi were being met from Yamuna till 1950. At present the demand for extra water is met from the storages of Bhakra and Ramganga. Further requirements from the year 2001 onwards could be met only by proposed storages at Tehri, Kishau and Renuka dams. The municipal and industrial water needs of Mumbai city are being met from dams at Bhatsa,Vaitrana etc. The Telugu Ganga Project is envisaged to supply 15 TMC of Krishna water to Madras for its drinking needs. Hyderabad city has plans to draw 5.5 TMC of Krishna waters. The supply of safe drinking water helps to reduce the incidence of water borne and vector diseases and efficiently conveyed water also improves water quality in areas where the geology affects the quality of water. This adds considerably to health standards.

Irrigation : The country needs 320 million tonnes of foodgrains in the year 2025 and 494 million tonnes by the year 2050. To achieve a production of this magnitude, irrigated agriculture is a necessity. Storage projects like Bhakra, Nagarjunasagar, Mettur, Hirakud and run of the river schemes with barrages on Ganga, Krishna, Godavari, Mahanadi, Cauvery, Sone etc have contributed significantly to increase food production and improve the standards of living of farmers. Irrigation also provides the means to increase bio-mass, provide more employment and improving quality of life.

Power Generation: Some water projects help in generating hydro-power which is renewable and does not use polluting fossil fuels. The installed capacity of hydropower has gone up from pre plan generation of 508 MW to 12,890 MW and is likely to rise further. Bhakra, Koyna, Idukki, Srisailam, Damodar Valley Corporation, Sherawati have contributed significantly to the power generation in the country.

Flood Control : Reservoirs have played an improtant role in managing floods. The rivers like Damodar and Kosi, known as rivers of sorrow of Bengal and Bihar respectively, have been tamed by construction of various water resources development structures. The construction of Ukai dam on river Tapi proved to be a boon to the people of Surat city.

Water Resources Projects and Climate : Water resources projects create large water bodies which modify micro climate both upstream and downstream. Investigations have shown that irrigation increases the moisture content in the surrounding air leading to increase in the humidity of the atmosphere. Water resource projects increase water availability and influence the environmental conditions.

Water and Recreation : Reservoirs are tourist attractions and places of recreation. Brindavan Garden at Krishnarajasagar dam (Karnataka) is a classic example. Many reservoir centres such as Mata Tila (U.P.), Jayakwadi (Maharashtra), Nagarjunasagar (Andhra Pradesh),Periyar(Kerala), Kabini (Karnataka) etc. have been developed as tourist resorts, some of them as game sanctuaries and parks.

Watershed projects: Integrated watershed projects help in water and soil conservation and thus enable restoration of degraded areas.

The negative or detrimental effects of water projects are project specific and vary from case to case but following is a general list. A combination of some of these occur in every project:

- Project construction in remote and often pristine areas involves cutting and blasting, establishment of colonies and induction of large number of people from outside. This results in increased deforestation, creation of gullies and steep slopes leading to erosion and land slides and, also deforestation, that disturb the lives of local inhabitants, though some of them are benefitted though employment and trade.

- The creation of a large reservoir (and the construction of a system of canals) means the submergence of land (agricultural or forest land, and also human settlements), displacement of people and their livestock, the loss of occupation, and other hardships.

- The 'stilling' of flowing water does bring about changes in the ecosystem e.g. temperature stratification, variation in nutrient content and dissolved oxygen at different levels etc. This may have an adverse effect on aquatic and riparian life which originally existed in the project area. Life forms new to the area may invade to the disadvantage of original life forms.

- Some reservoirs pose danger for wildlife through possibilities of drowning or marooning; habitats and routes of movement are disrupted; groups and interdependent species could be split and foodchains broken; some species could disappear, and this in turn could affect other species (communication links between human settlements could also be disrupted by the reservoir).

- Flora could also be affected through the construction processes, submergence and other factors. Some species (endemic and/or rare) could be endangered, and herbs and medicinal plants of local or wider importance may be lost. Taking the loss of forests and the impacts on flora and fauna together, there could be loss of bio-diversity.

- Presently the state of technical knowledge is such that dams can be built which can withstand any possible seismic activity in the area. However, an important issue on which there is difference of opinion is that of 'reservoir-induced seismicity' (RIS), for which adequate safeguards and planning are required under dam safety programme.

- The damming of a river affects the whole river regime. Flows as well as the silt load and nutrient content downstream of the dam would be substantially reduced, and this would have an impact on lives, occupations and livelihoods downstream (fisheries, the plying of boats, agriculture, settlements alongside the river, industries etc.). Estuarine conditions may also be adversely affected (erosion of biodiversity, the incursion of salinity from the sea etc.). The reduction of flows also means a deterioration of water quality and an increased concentration of pollutants in the river downstream of the dam. A further consequence of reduced flow is a decline in groundwater recharge.

- In some areas, due to construction of dams, structures of religious, historical or cultural importance may be in danger of submergence, and have to be shifted to safe places at great cost, though they could never be the same as before.

- All important dams are now being designed for probable maximum flood, and the probability of its being exceeded is remote. However, in older dams not adequately designed for peak flow, there may be overtopping and possible failure.

- The construction of canals, unless great care is taken, could disrupt natural drainage leading to drainage congestion. In the command area, the practice of canal irrigation for some years results in the emergence of waterlogging and salinisation, unless appropriate remedial measures are taken.

It is clear from the above list that while there are major benefits from water projects,there are also many costs in the form of impact on environment. The latter have to be minimised to the maximum extent possible, through adoption of alternatives and remedial and compensatory measures.

12.3 Environmental Impact Assessment

In order to assess the likely changes in the environmental conditions due to taking up of the projects, it is necessary to carry out environmental impact study. In each case an Environment impact assessment is an important tool to study the effects of a project on the environment. The Ministry of Environment & Forests through their Environmental Impact Assessment (EIA) Notification of 27.1.94 (as amended on 4.5.94) has, made the submission of 'Environmental Impact Assessment' (EIA) Statement and 'Environmental Management Plan' (EMP) mandatory, without which no project would be cleared for investment.

EIA is a formal process to predict the environmental consequences of a development activity and to plan appropriate measures to eliminate or remove adverse effects and to augment positive effects. EIA has three main features :

- To predict problems
- To find ways to avoid them and
- To enhance positive effects.

There is general agreement that proper EIA studies must be made in all cases; that this should be a part of project formulation *ab initio* and not an exercise to be undertaken to meet an external requirement after the project has been prepared; and that the EIA study should be an important element in the process of project appraisal. EIA is now a standard requirement, and both the Central Water Commission and the Ministry of Environment and Forests have laid down detailed guidelines on scope, coverage and methodology. A clearance by an Environmental Appraisal Committee under the Ministry of Environment and Forests is a pre-requisite for final investment approval to all big projects.

Once a full EIA is available, what is needed is the reckoning of all the environmental and displacement aspects as `costs' (in addition to the direct financial costs) and the balancing of these costs against the `benefits' which the project will bring (increased agricultural production resulting from irrigation, increased industrial activity made possible by hydroelectric power, their multiplier effects etc.) in a cost-benefit analysis.

Planning of a project has to include the formulation of detailed measures to remedy or mitigate or compensate for the adverse effects of the project. A catchment-treatment programme for arresting the deterioration of the catchment areas and restoring ecological balance and the resettlement and rehabilitation of displaced people need to be planned, exploring all alternatives.

12.4 Resettlement and Rehabilitation (R&R)

One of the most sensitive, complex and human questions that arises in large water projects is that of rehabilitation of persons displaced by submergence.

The National Water Policy (1987) recommended the following approach for R&R:

i) There should be an integrated approach to the planning, formulation, clearance and implementation of project and rehabilitation of affected people,

ii) Project should pay special attention to the needs of scheduled castes and scheduled tribes,

iii) Environmental impact assessment of each project should be made to reduce adverse impact on settlements, occupations and other aspects; and

iv) R&R programme and construction of project activities should proceed simultaneously and smoothly.

There are a number of guidelines on R&R aspects issued by the Union Home Ministry, Ministry of Welfare and Ministry of Labour. Ministry of Environment and Forests and Central Water Commission have also issued detailed instructions in this regard. The salient points of these guidelines include :

- The displaced person should not become a victim of development and that besides paying compensation, Government should take measures for their rehabilitation in such a way that there is no drop in their level of income. In fact, the efforts should be to go further and make them share the benefits of development by enabling them to improve their income.

- The Project Affected People (PAPs) must attain within a reasonable period of time a standard of living which is better than the standard enjoyed by them prior to displacement and which is in no way less than the general standard of living of the people in the area where they have been settled.

- In settling the PAPs, care must be taken to ensure that their social and ethnic ethos is not disturbed and their cultural integrity is preserved.

- A complete census of all categories, groups, communities and individuals affected in any manner, whatsoever, by the project to be conducted.

- Finding speedy, just and humane solutions to the problems of colony – affected people, "encroachers", the land rights of tribals, and the problems of landless labourers.

- Minimising dispersal of PAPs and ensure community settlement as far as possible.

- Even in those settlements where the number is less than 500, ensuring that people are provided with or given access to basic amenities and facilities such as schools, dispensaries etc.

- Making people's participation a reality through proper institutionalisation, including if possible, periodical public hearings in both submergence and resettlement areas.

- Independent monitoring and evaluation of R&R work.

- Full and timely flow of information to the people and the fullest co-operation with the NGOs.

- Preparation of a Master Plan with detailed time schedules for R&R.

As a measure of close compliance of these guidelines, to aviod suffering and hardship to the extent possible, the Courts have given directions on the matter of R&R.

The Supreme Court gave directions in the writ Petition No. 1021 of 1990 "that rehabilitation should be so done that at least six months before the area is likely to be submerged, rehabilitation should be completed and should be in respect of homestead, substitution of agricultural property and such other arrangements which are contemplated under the rehabilitation scheme".

The High Court of Gujarat in its judgement of April, 1993 ruled that there should be no forcible eviction, no temporary submergence and no temporary removal of oustees without completing rehabilitation as per the Award, the agreement with the World Bank, the Gujarat Government Resolutions and Supreme Court orders. The Court also ruled that submergence must not take place so long as the displaced persons are not properly rehabilitated.

The Narmada Water Disputes Tribunal Award also marked a significant change over earlier awards in as much as it went beyond the allocation of waters into questions of displacement and rehabilitation; and laid down norms and principles governing compensation and rehabilitation, which represented a vast improvement over earlier approaches.

In order to ensure that R&R activities receive the required attention, the Government of India have also issued relevant notifications and instructions in the matter. The environmental clearance of each project by the Ministry of Environment and Forests is subject to the condition that rehabilitation plans are so drawn as to be completed ahead of reservoir filling. Under the Environment (Protection) Act, 1986 and Environmental Impact Assessment Notification, 1994, the State Governments Project authorities are required to submit Environmental Impact Assessment Statements (EIA) and

Environmental Management Plan (EMP). These have to be implemented by the project authorities alongwith the construction activities of the project. These include preparation of master plans for rehabilitation of oustees, compensatory afforestation, alternatives in case of adverse effect on flora, fauna and wildlife, drainage and anti- waterlogging measures, identification of critically eroded areas for soil conservation and watershed development. The environmental impact needs to be assessed periodically, that is, every five years, during the implementation of the project and the project implementation agency is required to submit half yearly reports to the Impact Assessment Agency, about status of implementation of the above measures.

12.5 Deficiencies Noticed in the R&R Plan Implementation

Inspite of progressive pronouncements and genuine intentions, the R&R activities undertaken by different agencies appear to suffer from deficiencies. The more important of these are the following :

- Non-transparancy: At times even the displaced are not aware of the purpose for which the lands are being acquired.
- Non-involvement of the displaced especially the tribals, in the R&R activities.
- R&R plans are being implemented as a regular departmental activity with little coordination among the concerned departments/agencies.
- Non-involvement of the NGOs
- R&R plan not implemented and completed before the reservoir is filled.
- Less stress on rehabilitation measures and poor follow up after the displaced have been resettled.

It must also be said that, of late, there is a greater concern on the part of authorities regarding R&R activities. It is learnt that a national policy on R&R is under advanced stage of consideration of the Government of India.

12.6 Suggested Approach to R&R

Having considered the above, we would suggest the following to form the core of any R&R activity:

- The project authority should weigh all the alternatives and should only go in for the one that would cause the least disturbance. Special care should also be taken that the minimum extent of land required alone is proposed for acquisition.
- The R&R plan should be prepared alongwith the project but implemented well ahead of the project completion. There should be perfect timing so that all PAPs are settled well before the reservoir is filled in. R&R should be taken as the obligation we have to the people, who have to suffer on account of the project and should be dealt with as such with human compassion and sensitivity.

- The R&R project should receive sufficient funds, and implemented by a functional authority. It should be vested with powers to deal with the affairs of the state, to the extent, it is concerned.

- The project advisory steering committee must be broad based to include representatives of the PAPs, NGOs and representatives drawn from the concerned deparatments/agencies.

- Apart from periodic assessment of the R&R plan, there should be an assessment made five to seven years after its full implementation, to see how the PAPs have done for themselves. If further support/interventions are required, they must be provided.

- A complete survey of the affected zone and people, their occupation etc. should be taken in this respect, wherever tribals are involved.

- Compensation packages should be well laid down to take care of all categories of displaced persons. They would include land for land, homestead for all including the landless, cash compensation, training for vocations, employment and so on. As far as possible, cash compensation is not to be considered for tribals as they are tied to land in their way of life and are not careful in handling money.

- Tribals must be given special attention. They should as far as possible be settled in habitats, closer to the ones left behind by them and without breaking up their group identity.

- The resettlement sites should be well developed with all infrastructure so as to provide the resettled a better way of life.

- Support to the landless, unemployed should be extended, through appropriate means, to enable them to rehabilitate themselves.

- There should be active involvement of the displaced in the R&R activities; and flexibility to the extent required should be built into the plan.

- NGOs should be involved to the maximum extent possible, in the formulation, implementation and follow up of the R&R plan. They are based locally and will be able to build up the confidence of the resettled PAPs and reduce local tension between the locals and the resettled PAPs.

Much of the criticism against major developmental projects including water projects, emanate from poor R&R and, therefore, R&R of PAPs should receive total attention in the long term interests of the country.

12.7 Forest and Water Regime

Forests are a primordial component of environment and are important for soil and water conservation, protection of watersheds, improvement of drainage of command areas, conservation of biodiversity and moderation of regional environment. All aspects of environmental protection and social and economic development as they relate to forests should be integrated. About 30 percent of forest area is degraded which gives rise to serious problems such as flood, famine and drought.

Deforestation has taken place mainly due to transfer of land for developmental activities such as construction of dams, mining, industries and urbanisation etc.

The vital role of forests in protecting fragile ecosystems, watersheds, freshwater resources and as storehouse of rich biodiversity should be recognised. Trees, shrubs and other vegetation help to control temperature extremes by modifying solar radiation and increased relative humidity. Wetlands control flood, store and purify water and protect shores and hinterlands, floral and fauna habitats, gene pools, recreation besides providing commercial outputs to sustain rural communities.

The main strategy for conservation of species is the protection of viable habitats in representative ecosystems. *In-situ* conservation has been tried by establishing 316 preservation plots, about 7,200 sacred groves, 86 National Parks and 467 sanctuaries. *Ex-situ* conservation has been mostly applied to the rare, endangered, fast growing economically important species and medicinal plants with emphasis on land races. Arboretum, Botanical gardens, Parks, species /provenance trial areas, seed orchards, and clone banks conserve such species, green the area and improve the environment.

It is not yet definitely settled whether woodlands influence the amount of precipitation of a given area. Nevertheless, it is well known that so-called horizontal precipitation (from fog and dew) is considerably greater in forests than on treeless land. Forests build up litter, which is of great importance for the water regime. 'By increasing infiltration, forests decrease the maxima of surface runoff and reduce the intensity of moderate floods'.

The role of trees in the hydrological cycle has been and is being investigated throughout the world, and in general is fairly well understood. Such an understanding allows for manipulation, through forest management techniques, of catchment to increase water yields and recharge of groundwater. Agroforestry can improve bio-drainage of command areas saving productive land from waterlogging and salinisation.

There are about 75,000 species of animals including 50,000 insects, 4,000 molluscs, 2,546 fishes, 204 amphibians, 446 reptiles, 1,228 birds and 372 mammals and other invertebrates. A very large number of species listed are endemic to India. Among the larger animals 79 species of mammals, 44 of birds, 15 of reptiles and 3 of amphibians are threatened. The changes in river morphology and water quality brought about by stilling a flowing stream, and the impact of such changes on aquatic and riparian life, are difficult to be remedied. The decimation of fish population by damming of a river is also totally inescapable; fish ladder rarely works satisfactorily and the development of new reservoir fisheries cannot reduce biodiversity erosion. 'However, reservoirs provide favourable habitat for other varieties of fish and wild life. The availability of a perennial water body also helps the survival of land animal'.

India is the meeting place of three major bio-geographic realms, namely Indo-Malaya (the richest in the world), the Eurasian and the Afro-tropical. India owes the unique biodiversity to this unmatched interspersion of bio-geographic and environmental values.

North Eastern Regions of the Himalaya, Western Ghats and Andaman Nicobar Islands are classified as an ecological "Hot Spot", the term used to denote areas of ecosystems which are rich in biodiversity and possess rare and/or endangered species and endemic species. In the tropical rain forests, deciduous, temperate and alpine areas, there are over 300 families and 3,000 genera of flowering plants with more than 15,000 species of which 15 families and more than 330 genera are endemic.

India has a very long coastline extending over 6,000 Kms. Mangrove vegetation is characteristic of the estuarine tracts along the coast which sustain rich biological diversity. The threat to mangroves and coral reefs assumes the form of biotic pressures such as fishing, land use changes in surrounding areas and water pollution etc.

Conservation of biodiversity is a vital issue because it provides the basis of life on earth through genetic, species and ecosystems diversity. Equally important are vital life processes carried out by the nature including the stabilisation of climate, protection of watersheds and increasing productivity of soil.

In view of these considerations, before a dam is constructed, the following remedial measures are suggested for the conservation of flora, fauna and biodiversity:

- Comprehensive, multi-disciplinary study (covering flora, fauna, water quality and ecosystem and their inter-relationship) be undertaken to identify in detail the impact of project on the fauna, flora and biodiversity of the region.
- The study should be so designed as to cover at least two complete annual cycles and should be carried out with well established scientific methodology.
- If these studies throw up a need to minise the impacts of the project on any population, species or ecosystem, the activities should be appropriately restricted, slowed down or even suspended, if necessary.
- If endemic species are likely to be submerged, their *ex situ* conservation has to be planned
- *In-situ* conservation of endangered species has to be given priority.
- As far as possible, forest areas submerged in a catchment should be compensated by carrying out afforestation in the same ecosystem for restoring the integrity of the ecosystem

12.8 Internalisation of Environmental Concerns

Environmental concerns continue to be regarded as disagreeable external impositions and they have not become integral parts of the project planning from the start, despite many guidelines and instructions to this effect. Each project involves number of aspects and issues such as environmental protection, rehabilitation of project affected people etc.

Central Water Commission which is an apex body for water planning in the country is not a multi-disciplinary body encompassing agriculture, environmental science, economics, sociology, law etc. but is mainly a body of engineers. Similar conditions prevail in other institutes for better appreciation of the environmental and other concerns. It is necessary that these institutes should be multi-disciplinary.

To avoid delay in clearance of projects from environmental and forest angles as well as to ensure that safeguards stipulated by the Ministry of Environment and Forests while giving clearance are properly implemented, selected persons in water resource agencies both at the Central and State level should be trained to take care of these concerns and to prepare appropriate EIAs and EIPs and R&R plans. This would help to evolve specialised talent within the irrigation/water resource departments for preparing proposals and would help in the early clearance of projects from the environmental angle.

Water Resource Institutions should have close links with the institutions of the Ministry of Environment and Forests by mutual nomination of representatives on Governing Bodies / Technical Advisory Committees as well as by taking experts on short term/long term deputation. The infrastructure, personnel and training material in water resource training institutions should be strengthened to cover issues connected with the environmental aspects.

12.9 Water Quality

Until the 1950s, modern economic development largely ignored considerations of water quality, with the result that an inverse relation between development and water quality came into existence. Developed countries had to pay a heavy price to restore the quality of water in their rivers and other water bodies. Deteriorating water quality has become a serious problem in developing countries like ours also. Unless action is taken now, a much heavier price will have to be paid in future, especially due to the high density of our population.

Pollution of water results from many human, economic activities and development. An extended list of the causes would be somewhat as follows:

- Poorly treated and concentrated discharge of sewage, urban drainage water and industrial effluents.
- Agricultural practices including inorganic constituents and pesticides.
- The hidden chemical "time bombs" stored in soils and sediments with the potential to be remobilised by land use change, dredging or climate change.
- Loss or destruction of catchment areas.
- Intensive live stock production accumulating pungent animal waste in solid and liquid forms and their mixing with water.
- Nitrates as a major source of water contamination.
- Over exploitation of ground water in coastal and semi-arid areas causing salinisation and depletion of groundwater level.
- Mining and other extractive industries including mine water pumping, ore washing and effect of mine tailings.
- Destruction of wetlands, the natural filter of water.
- Oil spills from oil transport systems in the major rivers.
- Non - availability of minimum flow in the rivers reducing dilution capacity of rivers thus increasing pollution.

- Reduced flow of rivers and over exploitation of ground water in the coastal areas causing intrusion of saline water.

Water quality is basically determined by the bacterial and physico-chemical parameters. Water may be termed unfit for drinking purposes because of excessive salinity, brackishness, fluorides, sulphates, hardness, nitrates, iron, manganese and pesticides. Water of poor quality leads to ill-health and water in insufficient quantity claims large chunks of time spent in augmenting the supply-time that could be spent on more remunerative tasks.

Safe water-supplies and environmental sanitation are vital for protecting the environment, improving health and alleviating poverty. According to various studies, an estimated 80 percent of all diseases and over one third of deaths are caused by consumption of contaminated water, and, on an average, as much as one tenth of each person's productive time is sacrificed to water-related diseases.

The Mar del Plata Action Plan (adopted by the United Nations Water Conference in 1977) recognised the intrinsic linkage between water resource development projects and their significant physical, chemical, biological, health and socio-economic repercussions. The overall environmental health objective was set as: "to evaluate the consequences which the various users of water have on the environment, to support measures aimed at controlling water-related diseases and to protect eco-systems".

The International Drinking Water Supply and Sanitation Decade was launched in 1981 with the aim that "all peoples, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs". The target of the Decade was to provide safe drinking water and sanitation to under served urban and rural areas by 1990, but even the unprecedented progress achieved during the decade was found to be inadequate.

12.10 Water Quality Criteria and Standards

Water quality criteria have been developed for various categories of beneficial uses ranging from drinking water, outdoor bathing, propagation of wildlife and fisheries, irrigation, industrial cooling and controlled waste disposal. The relevant parameters are colour, odour, floatable material, pH, Phenols and hydro carbons. The water quality standards developed by the CPCB for different uses are given in Table 12. 1.

Table - 12.1

Primary Water Quality Criteria

Designated Best Use	Class of Water	Criteria
Drinking water source without conventional treatment but after disinfection	A	1. Total Coliform Organisms MPN/100 ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0 C 2 mg/l or less
Outdoor bathing (Organised)	B	1. Total Coliform Organisms MPN/100 ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0 C 3 mg/l or less
Drinking Water with conventional treatment followed by disinfection	C	1. Total Coliform Organisms MPN/100 ml shall be 5000 or less 2. pH between 6 and 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0 C 3 mg/l or less
Propagation of wild life fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste Water disposal	E	1. pH between 6.0 and 8.5 2. Electrical conductivity @ 25^0 C : 2250 micro mhos/cm, Max 3. Sodium absorption ratio, Max 26 4. Boron, Max 2 mg/l

Source: Central Pollution Control Board (1991)

Based on the long term water quality data generated over the years, 13 heavily and 26 medium polluted rivers and 26 medium polluted river's stretches have been identified in the country. The critical pollutants identified for the polluted river stretches are dissolved oxygen, bio-chemical oxygen demand and total coliforms. In most of the rivers these parameters are not adequate to indicate the overall health of a water body. "Bio-maps" based on bio-assessment depict the stretches where the deterioration of water quality has occurred and where action for improvement is needed.

12.11 Water and Health Related Issues

Almost half of the world's population suffers from diseases associated with insufficient or contaminated water. Safe water supplies and environmental sanitation are vital for health. Important water borne diseases are hepatitis-A, cholera, typhoid, polio, diarrhoeal diseases and amoebiasis. Important water associated diseases include malaria, filaria, dengue, polio myelitis, heiminthic and infectious hepatitis.

The safe drinking water supply schemes brought about improvement in the quality of water for domestic use and brought down mortality due to cholera, typhoid and diarrhoeal diseases. Yet, the fast growing urbanisation, lack of water delivery and sanitation facilities, in addition to poor system maintenance, are resulting in severely contaminated water and increasing incidence of water-related diseases. In the present urban environmental situatition, India faces a health scenario in which its urban population is under major health risks. These include widespread but preventable communicable diseases. In large cities such as Mumbai,Delhi and Calcutta contamination of water in piped distribution system and in user-storages like sumps and overhead tanks due to inadequate maintenance has resulted in high rates of water-borne infection, including diarrhoea and enteric disease. Degradation of water quality from industrial and domestic pollution is another major cause of environment-related illness. Release by industry of untreated toxic organic and inorganic waste water pollution into water courses is a widespread problem.

Similarly, groundwater related issues, although gradual in impact, require immediate consideration specially in rural areas where majority of population is dependent on this source. The pollution from these sources is generally of two types: one inherent in the form of contamination caused by the very nature of geological formation - Excess fluoride, excess arsenic and excess iron causing suffering to large population fall under this category; the other caused by human interference (anthropogenic) - Some of the examples are excess application of chemical fertilizers having high amount of Nitrogen in the agricultural sector, untreated domestic sewage causing biological contamination, discharge of untreated industrial effluents and excess pumping of groundwater in coastal areas leading to brackishness.

Improving the quality of drinking water, ensuring proper sewage disposal and providing more water for both personal and domestic hygiene are keys to prevention or control of major diseases such as diarrhoeal diseases, cholera, typhoid, Guinea-worm diseases, hepatitis, polio, filiaria, dengue and malaria.

The concept of bio-mapping has been introduced by CPCB for the production and detection of ecological effects and to protect rare and endangered biotic species surviving in surface water from evergrowing pollution. Bio-mapping is the technique of transformation of biological water quality information of a river basin in the form of a coloured map. Different colours on a river basin map, such as blue, light blue, green, orange and red, indicate various water quality classes in terms of clean, slight pollution, moderate pollution, heavy pollution and severe pollution of a water body respectively.

12.12 Biological Water Quality Criteria (BWQC)

To assess the actual health of water bodies, CPCB has derived Biological Water Quality Criteria (BWQC) for water quality evaluation. This system is based on the range of saprobic values and diversity of the benthic macro-invertebrate families with respect to water quality. The system has been developed after extensive field trials and calibration on the saprobity and diversity information of different taxonomic groups of benthic animals collected from artificial substratum and natural substratum of various water bodies. To indicate changes in water quality to different grades of pollution level, the entire taxonomic groups, with their range of saprobic score from one to ten, in combination with the range of diversity score from 0 to 1 has been classified into five different classes of water quality (Table 12.2). The abnormal combination of saprobic score and diversity score indicates sudden change in environmental conditions.

Table - 12.2

Biological Water Quality Criteria (BWQC)

S.No.	Taxonomic groups	Range of saprobic score (BMWP)	Range of diversity score	Water quality character-stitic	Water quality class	Indicator colour
1.	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Diptera	7 and more	0.2 – 1	Clean	A	Blue
2.	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Planaria, Odonata, Diptera	6-7	0.5-1	Slight Pollution	B	Light Blue
3.	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Odonata, Crustacea, Mollusca, Polychaeta, Coleoptera, Diptera, Hirudinea, Oligochaeta	3 –6	0.3-0.9	Moderate Pollution	C	Green
4.	Mollusca, Hemiptera, Coleoptera, Diptera, Oligochaeta	2-5	0.4 & Less	Heavy Pollution	D	Orange
5.	Diptera, Oligochaeta No animals	0 – 2	0 – 0.2	Severe Pollution	E	Red

Source: Central Pollution Control Board's Report.

Using a combination of these criteria, quality standards for the rivers are in process of development. The guidelines issued by the Ministry of Environment and Forests, Government of India include various items listed below :

I. For Rivers where no pollution abatement programme is initiated or proposals received, data under GEMS & MINARS from CPCB/SPCB may be used

II. For rivers where pollution abatement works are undertaken

a) The monitoring should be done once in a month preferably on the 11th day at 30 cm depth from the surface.

b) For baseline stations and trend stations, the water samples should be drawn from midstream and for impact stations, samples should be collected from 1/4th and half width of the river.

c) Samples may be analysed for pH, conductivity, temperature, velocity, discharge (wherever possible), DO, BOD, COD, chloride, total coliform, faecal coliform, faecal streptococci (FC/FS ratio), site specific heavy metals.

d) Seasonal monitoring of drains for waste water analysis within the action plan towns should be included as part of water quality monitoring.

e) NRCA may organise more frequent training programmes on WQM, PFR preparation and treatment technologies.

f) A training programme on heavy metals, pesticides, sediments and drain monitoring for all the project investigators should be organised at least once a year.

g) A mid course correction on water quality monitoring strategy be carried out.

h) Selection of monitoring stations for U/S, D/S of town, any strategic point in between U/S and D/S including abstraction, water intake, tributary, major polluting source or discharge of treated waste water from STPs.

i) Important bathing ghats – at least one ghat per religious town be added to monitoring stations. Samples to be taken from two to five m from the bank and analysed for pH, temperature, DO, BOD, total coliform and faecal coliform.

III. For towns/rivers where STPs are completed, commissioned and operationalised

Performance monitoring of sewage treatment plants on monthly basis retained. Data may be compared with that of the implementing agency.

Once a year, a sanitary survey including wastewater characterization, to know the additional source of pollution.

IV. For towns identified as per Supreme Court Orders and where only non-core activities shall be undertaken

The water quality monitoring may be done for post-monsoon, summer and winter seasons with analysis for temperature, pH, DO, BOD, total coliform and faecal coliform.

12.13 Water Quality Monitoring

Monitoring the quality of rivers and other water bodies is the most essential first step in restoring water quality. The Central Pollution Control Board (CPCB) has a nationwide responsibility of water quality monitoring and management of rivers. The existing water quality monitoring network in India includes 495 monitoring stations located in various water bodies all over the country. The water quality at these stations is monitored through three major schemes namely,

i) Global Environmental Monitoring System (GEMS) – 50 monitoring stations are operated.

ii) Monitoring of Indian National Aquatic Resources System (MINARS) – 430 monitoring stations are operated.

iii) Yamuna Action Plan (YAP) – 15 monitoring stations are operated.

All these monitoring stations are distributed on various natural aquatic resources. In all 164 stations are located on major, medium and small rivers, 185 stations on tributaries and 71 stations are located on independent rivers. Other than rivers, the water quality network also covers the water quality monitoring of lakes at 35 locations, ground water sources at 24 monitoring locations and 16 monitoring locations on other sources. The entire water quality monitoring is performed through State Pollution Control Boards, and CPCB zonal offices. At present the water quality monitoring is undertaken for 23 physico-chemical parameters at monthly/quarterly interval.

The CWC is maintaining a large network of 877 hydrological observation stations in the key locations of the river basin systems of India for reliable assessment of the water resources of the country. Out of these, 319 stations distributed over all the major river basins, are also engaged in water quality monitoring. Initially, the water quality monitoring of CWC was started with the limited objective of classification of water for irrigation and other related uses, but presently, it also includes monitoring the rate of silt flows, chemical indices like sodium absorption ratio, sodium percentage, residual sodium carbonate and hardness number as well as other pollution parameters. However, the monitoring does not cover the municipal and industrial effluents. The CWC is also maintaining a three-tier laboratory system for analysis of the chemical parameters of water quality monitoring.

Ground water quality is being monitored by the CGWB through a network of 14,995 monitoring stations set up in different parts of the country. Changes in water quality have been observed in major agricultural and industrial belts and urban complexes as a result of overuse of fertilizers, pesticides and insecticides in agriculture and disposal of untreated waste from industries and urban cities. Although all these organisations are engaged in the same task, they are, nevertheless, working in isolation and without interaction as well as coordination on a continuing basis. There is need to set-up a mechanism to effectively coordinate the work of water quality monitoring by these organisations, so as to cover the whole gamut of water quality for a complete analysis to decide upon corrective / remedial measures.

12.14 Remedial Action

To restore and maintain water quality and ensure environmental sustainability, action is needed on a wide front. The challenges are many but are not beyond the present status of our knowledge of science and engineering or of social sciences. We give below in a summary fashion the more important of the actions to be taken, even though some of them have been stated in other contexts in this report.

Water Resources Protection and Conservation

- Rain water harvest structures be encouraged in a big way to increase availability of water and also increase groundwater recharge for better sustainability of water sources.

- Water supply links with watershed development programmes should be made more effective for better sustainability of drinking water sources.

- Conservation of water by better management to reduce leakages and pilferage and recycling of treated waste water for non-domestic uses be encouraged by giving incentives. This will not only save precious water but also reduce load of water/sewage treatment units.

- Over exploitation of groundwater must be avoided to control deterioration of its quality and reduced cost of pumping. Regulatory mechanism for groundwater exploitation to be brought in by the State Government in such areas which are facing acute shortage of drinking water throughout the year, for better sustainability of the sources of water.

- Establishing and strengthening of technical and institutional capacities to identify and protect existing and potential sources of water supply, in all sectors of our activities.

- Preparation of national plans for water resources protection and conservation.

- Rehabilitation of important, but degraded, catchment areas.

- Strengthening of administrative and legislative measures to prevent encroachments on existing and potentially usable catchment areas.

Water-Use Efficiency

- Increase of efficiency and productivity in agricultrual water use for better utilisation of limited water resources.

- Strengthen water and soil management research under irrigation and rainfed condition.

- Support water user groups with a view to improve management performance at the local level.

- Support the appropriate use of relatively brackish water for irrigation.

Water Quality Management

- Establish and operate cost-effective water quality monitoring systems for agricultural and industrial uses..

- Prevent adverse effects of agricultural activities on water-quality for other social and economic activities and on wetlands inter-alia through optional use of on-farm input and minimisation of the use of external input in agricultural activities.

- Establish biological, physical, chemical water quality criteria for agricultural and other water users and for marine and riverine eco systems.

- Minimise soil runoff and sedimentation.

- Dispose properly, sewage from human settlements and manure produced by intensive livestock breeding.

- Minimise adverse effects from agricultural chemicals by use of pest management.

- Educate communities about the pollution-related impacts of the use of fertilizers and chemicals on water quality, food safety and human health.

Waterlogging, Salinity Control and Drainage

- Introduce surface drainage in rain fed agriculture to prevent temporary water logging and flooding of low lands.
- Introduce artificial drainage in irrigated and rainfed agriculture.
- Encourage conjunctive use of surface and ground water, including monitoring and water balance studies
- Practise drainage in arid and semi-arid regions.

Water Pollution Prevention and Control

- Application of "polluter pays" principle, where appropriate, to all kinds of sources, including on-site and off-site sanitation.

- Promotion of the construction of treatment facilities for domestic sewage and industrial effluents and development of appropriate technologies, taking into account sound traditional and indigenous practices.

- Establishment of standards for discharge of effluents and for the receiving water.
- Introduction of precautionary approach in water-quality management, where appropriate, with a focus on pollution minimisation and prevention through use of new technologies, product and process change, pollution reduction at source and effluent reuse, recycling and recovery, treatment and environmentally safe disposal.

- Mandatory environmental impact assessment of all major water resource development projects potentially impairing water quality and aquatic ecosystems, combined with the delineation of appropriate remedial measures and a strengthened control of new industrial installations, solid waste landfills and infrastructure development projects.

- Use of risk assessment and risk management in reaching decisions in this area and ensuring compliance with those decisions.

- Identification and application of best environmental practices at reasonable cost to avoid diffuse pollution, namely through a limited, rational and planned use of nitrogenous fertilizers and other agro chemicals (pesticides, herbicides) in agricultural practices.

- Encouragement and promotion of the use of adequately treated and purified waste water in agriculture, aquaculture, industry and other sectors.

Development and Application of Clean Technology

- Control of industrial waste discharges, including low-waste production technologies and water recirculation, in an integrated manner and through precautionary measures derived from a broad based life-cycle analysis.

- Treatment of municipal waste water for safe re-use in agriculture and aquaculture.

- Development of biotechnology, inter-alia for waste treatment, production of biofertilizers and other activities.

- Development of appropriate methods for water pollution control, taking into account sound traditional and indigenous practices.

- Identification of cleaner technologies developed and facilitating transfer and adaptation of such technologies in India.

- Capacity building for environmental audit for pollution prevention.

Groundwater Protection

- Development of agricultural practices that do not degrade ground water.

- Application of the necessary measures to mitigate saline intrusion into aquifers of small islands and coastal plains as a consequence of sea level rise or over exploitation of coastal aquifers.

- Prevention of aquifer pollution through the regulation of toxic substances that permeate the ground and the establishment of protection zones in ground water recharge and abstraction area.

- Regulation of industries based on ground water or disposing off solid or liquid waste from the standpoint of water use (already in force) and also from the angle of pollution of ground water and recycling.

- Design and management of landfills based upon hydrological information and impact assessment, using the best practicable and best available technology.

- Promotion of measures to improve the safety and integrity of wells head areas to reduce intrusion of biological pathogens and hazardous chemicals into aquifers at well sites.

- Water quality monitoring, as needed for surface and groundwater, potentially affected by sites storing toxic and hazardous materials.

- Establishment of network for the monitoring and continuous surveillance of waters receiving wastes and of point and diffuse sources of pollution.
- Promotion and extension of the application of environmental impact assessments of geographical information systems.
- Surveillance of pollution sources to improve compliance with standards and regulations to regulate the issue of discharge permits.
- Monitoring of utilisation of chemicals (fertilizers and pesticides) in agriculture that may have an adverse environmental effect.
- Rational land use to prevent land degradation, erosion and siltation of lakes and other water bodies.

We have dealt with many of the above points in the appropriate chapters and the more important ones in this chapter.

12.15 Cause and Effect of Water Quality Deterioration

Some of the root causes of water quality deterioration are:

- Ignorance of the full cause/effect relationships of water pollution.
- Wilful misuse of water sources.
- Failure to appreciate that water is a near universal solvent and as it moves through both man-made and natural environment, it picks up and transports in solution and suspension, a wide variety of organic and inorganic substances; when uncontrolled, this frequently leads to serious pollution.
- Failure to mimic nature's natural closed cycle operation. Mankind uses open loop systems. We flush vast quantities of water through urban areas, industries and agricultural areas, polluting water in the process. Then we return this polluted water, often as point discharges, to the natural aquatic environment in such concentrations that the latter's natural capacity to absorb and convert pollutants is exceeded.
- Pipeline based system concentrates the polluted run off waters and unless controlled puts the contaminated effluents back into the natural aquatic environment in a diffused set of point discharges which cause widespread pollution.

The deteioration of water quality has several adverse effects, as for example:

- Bacterial or microbial contamination of water, causing widespread sickness and death from water borne diseases.

- Loss of natural aquatic habitats and chronic human health risks from pollution by toxic substances that is, chemical contamination (metals, synthetic and industrial pollutants and radio active substances).
- Loss of productive capacity of irrigated soil through water logging and salinisation.
- Loss of biodiversity in aquatic environment.

12.16 Sustaining Rivers, Lakes and Wetlands

Rivers, lakes and wetlands are the important natural sources of water. Maintaining water quality in them is indeed vital for all life. A number of programmes have been initiated to restore water quality and sustain our rivers, lakes and wetlands. The more important ones among them and the lessons drawn from the experience so far are briefly discussed below.

Rivers

Most of the major rivers in the country suffer from pollution in one stretch or the other. The Ganga was considered to be one of the most polluted rivers in the country. A study conducted by the CPCB in 1984 concluded that nearly 75 percent pollution of the river was on account of discharge of untreated municipal sewage into the river from the large and medium towns located along it and the remaining 25 percent pollution was caused by the discharge of partly treated/untreated effluents from the industry. The report also identified that some of the non point sources of pollution include items such as run-off from agricultural fields carrying chemicals and fertilizers, run off from areas used for dumping of solid waste and open defecation, dumping of burnt/half burnt dead bodies and animal carcasses, dhobi ghats, cattle wallowing, mass bathing, floral offerings, etc.

The river cleaning programme of India was started with the launching of the Ganga Action Plan (GAP Phase-I) in June, 1985 as a 100 percent Centrally Sponsored Scheme to restore the river water quality to the following standards:

Biochemical Oxygen Demand (BOD)	3	mg/l	maximum
Dissolved Oxygen (DO)	5	mg/l	minimum
Total Coliform	10,000	MPN per 100 ml	
Faecal Coliform	2,500	MPN per 100 ml	

To tackle the pollution of Ganga from municipal sewage, pollution abatement works were taken up in 25 Class I Towns (population above one lakh in 1985). Of these, six are in Uttar Pradesh, four in Bihar and 15 in West Bengal. Out of the approved cost of Rs.462.04 crores, an amount of Rs.450 crores was spent on the programmes upto March, 1999. The main aim of the action plan was the interception and diversion for treatment of 873 million litres per day (mld) of municipal sewage out of the estimated 1,340 mld (both Feb., 1985) from these 25 towns. The remaining sewage was to be taken up under the Second Phase of GAP. The action plan included schemes of construction and improvement of bathing ghats to provide a clean hygienic access to the rivers. Pollution of the river from grossly polluting industry was to be managed and controlled under the existing environmental laws.

To accomplish the task, 261 schemes of pollution abatement concerning municipal activity were sanctioned under GAP I. These included 88 interception and diversion, 35 sewage treatment, 43 low cost toilets, 28 electric crematoria, 35 river front development and 32 schemes of miscellaneous category.

Initially it was expected that the programme would be completed in six to seven years. However, it was delayed considerably due to the following reasons:

- Being the first programme of its kind and magnitude, there was a lack of experience both at the Central and State level.
- There were inordinate delays in land acquisition for major schemes of sewage treatment and dumping stations in Calcutta, Bhatpara, Cossipur-Chitpur and South suburban (east) segment of Calcutta in West Bengal and Patna and Munger in Bihar.
- Litigation and court cases mainly in Kanpur and Allahabad in U.P. and Cossipur-Chitpur in West Bengal resulted in considerable delays.
- Two sites of major projects, one in Calcutta and the other in Patna, were under encroachment for a long period.
- The schemes of all seven sewage treatment plants in Bihar and West Bengal had to be tendered several times. In addition, there were contractual problems in four out of 13 major sewage treatment plants of UP.
- Externally aided components of Kanpur and Mirzapur projects were prolonged considerably due to delay in initial formalities between the Governments.
- Diversion of funds by the State Governments of U.P. and Bihar resulted in the delayed release of central funds to the States for implemention of the programme.

However, with the ultimate completion of 254 schemes, the water quality of Ganga has shown improvement over the pre-GAP period quality in terms of both the Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO), the two important parameters to assess river water quality.

Despite the problem of Operation and Maintenance in UP and Bihar, the improvement in river water quality can be attributed to have been achieved as a result of diversion of large quantities of sewage in towns like Kanpur, Allahabad and Varanasi for sewage farming.

Although river water quality along Kanpur and Varanasi has improved significantly, it still does not meet the prescribed standards of BOD of 3 mg/l. This is mainly because, a) only 160 out of 360 mld at Kanpur and about 100 out of 180 mld of sewage at Varanasi has been taken up for interception and diversion under GAP Phase-I; and b) the river stretch from Farukhabad to Varanasi in general and Kanpur in particular is critical in terms of the availability of desired minimum flow for dilution purposes.

12.17 Deficiencies in Operation and Maintenance

Notwithstanding delays, pollution abatement facilities were completed. However, following major deficiencies have arisen in operation and maintenance :

- States, particularly Bihar and to a large extent U.P., are unable to provide timely adequate funds for operation and maintenance of assets created under the programme.
- In Bihar, the O&M has been grossly inadequate in respect of all the assets. The state government has neither been able to provide funds for such purposes nor the required power on a continuous basis for operation of assets like sewage treatment plants, pumping stations, crematoria etc.
- O&M of conveying sewers and intermediate pumping stations which is equally cost intensive has been grossly neglected in UP due to the inability of State Government to provide adequate funds. As a result, despite the facility being available, sewage is still finding its way into the river at several places.
- Erratic and poor availability of power is a major bottleneck in operating the pumping stations, STPs and electric crematoria.
- O&M of other facilities like toilets and bathing ghats has been neglected in general by the local bodies. They have also not been able to discharge other civic functions in GAP towns in a manner desirable in maintaining the town and in keeping the river clean.
- The stretch of river from Farukhabad to Varanasi in general and Kanpur in particular is very critical in terms of availability of minimum flow. Therefore, the dilution capacity of the river is severely limited, with the result that the desired quality of water could not be obtained at Kanpur.
- It has been possible to minimise the organic pollution (which is indicated by BOD) reaching the river through the intervention of GAP. However, there has been only incidental reduction in the treated sewage in respect of microbial pollution (which is indicated by the coliform counts).

12.18 Corrective Measures Needed

The following measures are needed to improve the functioning of these schemes:

- The Operation and Maintenance (O&M) of assets created under Ganga Action Plan needs urgent attention for improvement. Assigning the responsibility for O&M to one agency would increase efficiency.
- Sanctioned funds for maintenance may be transferred from the State Government to the local bodies concerned.
- Greater reliance may be placed on alternative technologies which are not driven by conventional power, for example Waste Stabilisation Pond Technology, Upflow Anaerobic Sludge Blanket, sewage treatment through plantation, aquaculture using duck weed etc. to overcome the problem of erratic power supply.
- Measures may be taken to ensure a minimum flow of fresh water in the major rivers during the lean season.

12.19 Ganga Action Plan (Gap-Phase-II) and National River Conservation Plan (NRCP)

The Ganga Action Plan model (Phase-I) with necessary changes on the basis of lessons learnt and experience gained has been applied to all the major rivers of the country under two schemes of GAP- Phase II and the National River Conservation Plan (NRCP).

These programmes were approved on an equal cost sharing basis between the Centre and State Governments. However, considering the difficulty of the State Governments in providing share of the cost, the National River Conservation Authority (NRCA) decided to convert the schemes into 100 percent Centrally funded programmes on the lines of GAP– Phase-I. This was approved by the government in November, 1998 with the modification that the cost of land (with effect from 1.4.1997) was to be borne by the concerned state government.

Under GAP Phase-II, the following works have been taken up in 95 towns in five states covering the following four major rivers of Ganga basin:

- Major tributaries of the river Ganga viz. Yamuna, Gomti and Damodar.
- Works in the remaining large towns located on the main stream of Ganga which are responsible for its pollution and remaining works in some of the 25 GAP Phase-I towns, which could not be taken up under Phase-I.
- Works in the additional 30 towns covered by Supreme Court Orders.
- Common Effluent Treatment Plant (CETP) for the Calcutta leather complex included under the Supreme Court Order.

The approved cost of this programme is Rs.1,276.25 crores.

Under NRCP, pollution abatement works in 18 rivers and 46 cities in 10 states have been taken up as per the Table 12.3.

TABLE – 12. 3

STATEWISE SANCTIONED COST OF NRCP

S.No.	Name of the State	River	Number of Towns	Sanctioned Cost (Rs. In crores)
1.	Andhra Pradesh	Godavari	4	51.15
2.	Bihar	Subarnarekha	3	30.64
3.	Gujarat	Sabarmati	1	93.83
4.	Karnataka	Bhadra (Kabini), Tunga, Tungabhadra	8	20.62
5.	Madhya Pradesh	Betwa, Chambal, Khan, Kshipra, Narmada, Tapti & Wainganga	11	94.51
6.	Maharashtra	Krishna, Godavari	4	162.68
7.	Orissa	Brahmani & Mahanadi	4	23.55
8.	Punjab	Satluj	4	219.62
9.	Rajasthan	Chambal	2	16.93
10.	Tamil Nadu	Cauvery	5	41.37

The modifications effected in the GAP Phase II and NRCP schemes on the basis of GAP Phase-I experience include the following:

- System designs have been planned on the basis of actual survey and estimation of waste water generated from towns.
- Decentralised approach has been adopted for each segment for interception, diversion and treatment of polluted water to optimise the cost.
- States have been advised to ensure that land acquisition activity is completed in time.
- Adoption of cost effective and appropriate technologies like Upflow Anaerobic Sludge Blanket (UASB), Stabilisation Ponds and Karnal Technology, wherever feasible. This will improve the sustainability of the programmes.
- Maintenance of minimum flow and other requirements of River Action Plan are kept in view while equipping large development projects.
- Improved wood based crematoria have been adopted in place of electric crematoria which were found not popular in many towns and also due to non availability of uninterrupted power supply.
- Setting up of low cost toilet complex on the basis of physical surveys. The operation and maintenance of such schemes is proposed through reputed NGOs.
- Training programme in project management has been designed and introduced to train the project managers to minimise the implementation period.

- Greater emphasis is placed on the public awareness and participation and involvement of people.
- Privatisation of O&M and few STPs proposed on experimental basis.
- Strict water quality monitoring to be adhered to on regular basis

If faithfully implemented, these measures would very susbstantiallly help in the success of the NRCP.

12.20 Lakes

Lakes constitute an important component of our fresh water systems. Due to pressures of human activities, a number of lakes are shrinking or getting polluted beyond the point of recovery. Encroachment, siltation, weed infestation, discharge of domestic sewage, industrial effluents and surface runoff carrying pesticides and fertilizers from agricultural fields are among the major threats. The symptoms of the pressures due to encroachment and invasions are already experienced in the form of decrease in the migratory bird population, fish and other fauna, poor water quality and prolific growth of obnoxious weeds.

On experimental basis it is proposed to take up rehabilitation of Dal Lake in J & K State. Alternative Hydro Energy Centre, Roorkee has been selected to undertake preparation of detailed project report in consultation with the State Government. So far an amount of Rs.25 crores has been released to the State Government for starting the work.

The objective of National Lake Conservation Programme is to arrest further degradation of lakes and to revive the water body to acceptable environmental standards so that water can be utilised for different purposes. This programme needs to be expanded on the basis of experience of initial projects.

12.21 Wetlands

Wetlands are areas of marsh, fen, petlands whether natural or artificial, permanent or temporary with water, that is static or flowing, fresh, brackish, including marine waters not beyond six metres deep. Wetlands control flood, store and purify water and protect shores and hinterlands to sustain rural communities. Indian wetlands which represent various geographical regions dot the cold zone of Ladakh, warm arid zone of Rajasthan, tropical monsoonic central India, wet north eastern region, wet southern peninsula and the coastal wetlands.

Wetlands of all types are natural filters. They are excellent systems for converting waste streams back into the natural environment, in both agricultural and urban areas. There are about 17 million hectares of wetlands (about 14.05 m ha natural and 2.59 m ha man made) in the country. According to estimates, only 28 percent of the area of 93 wetlands is under total protection. This does not include a vast number of small, scattered aquatic habitats throughout the country. Thus it has not been able to cover city tanks, rural irrigation water bodies, lagoons, coastline habitats and other sensitive wetland habitats of bio-diversity importance. Out of 85 wetland sites of international importance in the country, 45 percent are subjected to moderate to high threat.

The problems faced by wetlands relate to weed infestation, siltation, eutrophication, encroachment, chemical and organic pollution and anthropogenic activities. Wetland may have several values such as groundwater recharge and maintenance of water quality; dependence of agriculture and animal husbandary in drought prone areas; conservation of rare and endangered species; pollution abatement; flood control etc. Ecologically, wetlands may be viewed as more important ecosystem, transitional between open water and terrestrial ecosystems, endowed with specific structural and functional attributes, and performing major ecological role in the biosphere.

Wetlands have to be regenerated by the reorientation of policy of "open access" to "common property resources". Currently, these are often drained to create agricultural land and habitation places. Other protection measures may include:

- Conservation and protection of wetlands (owing to their ecological and habitat importance for many species) taking into account social and economic factors.
- Control of noxious aquatic species that may destroy some other water species.
- Development of appropriate methods for water pollution control, taking into account sound traditional and indigenous practices.
- Rehabilitation of improved, degraded catchment areas particularly of small islands.

A National Committee on Wetlands, Mangroves and Coral Reefs was created to advise the government on appropriate policies and programmes for the conservation and management of wetlands. 22 wetlands have been identified as priority areas for conservation and improvement under the Wetland Conservation Programme. Of the 22 wetlands, four fall within the urban areas and require special treatment for pollution control. The wetlands programme needs to be strengthened with additional outlays.

CHAPTER-13

RESEARCH AND DEVELOPMENT NEEDS

For sustaining any human endeavour efficiently over a period, continuous research and development is essential. This becomes even more necessary in the water sector because of special attributes. Integrated approaches to water resources development and management are complex and require much more than solely integration within the water domain itself. The new concepts bring with them a call for unified policies, participatory processes, integrated information and a greater emphasis on social and environmental concerns. While the concepts may well be accepted, their implementation remains problematic. Institutional and human capacities at national and local level are critical for effective implementation. Institutional capacity implies strong legislative and regulatory frameworks supported by effective enforcement. Similarly, human resource development provides a means of creating and strengthening the assimilation of new knowledge and ultimately to manage the resource.

Capacity building and human resource development have been the subject of many national and international events. The emphasis on these aspects is likely to grow as the move from policy based initiatives to actual implementation gains momentum. It is essential that human resource development is focused at all levels. The call for integration and decentralisation will place great demands on existing resources at all levels and these will need to be addressed, together with the financial resources to support them (Global Water Partnership- Framework for Action, July 1999).

In this chapter, we discuss the research and development needs relevant to the water sector as a whole, take stock of the present status of research and development activities, bring out the main achievements, consider the issues which might arise in the future and indicate how research and development policies need to be adjusted to focus on these issues.

In the past, R&D activities in water sector in India concentrated mostly on technological aspects, while action research, policy analysis and research on the supporting human resources development activities did not get sufficient attention.

The area on which research and development is to be focussed would itself change with time as new problems develop and are recognized by the policy makers. Within each area, there would be a list of items on which research would be required. However, with the uncertainties involved in the process, it would not be possible to draw up a detailed agenda for research in terms of researchable topics. The attempt here is to indicate broadly the areas requiring research focus, and wherever possible, indicate specific issue or subject for research, investigation and development.

We also attempt to outline an approach to human resource development in the water sector as a whole, including all types of activitities like planning, design, construction, operation and management as well as research.

I. Research and Development

13.1 General

In general, research and development activities are required to discharge two important functions. The first is to effectively solve a problem and the second is to give a continuous feedback to the policy makers for changing water policies towards improved water development and management.

Although these functions are recognized as distinct, they are inter-related and one function cannot be discharged effectively unless the other is also addressed.

The inter-active research and development process for problem solving is charted out in Figure 13.1. The importance of research and development activities and the data management activities in water sector in evolving water policies is depicted in Figure 13.2.

Fig.13.1: The Research & Development Process as Problem Solving Tool

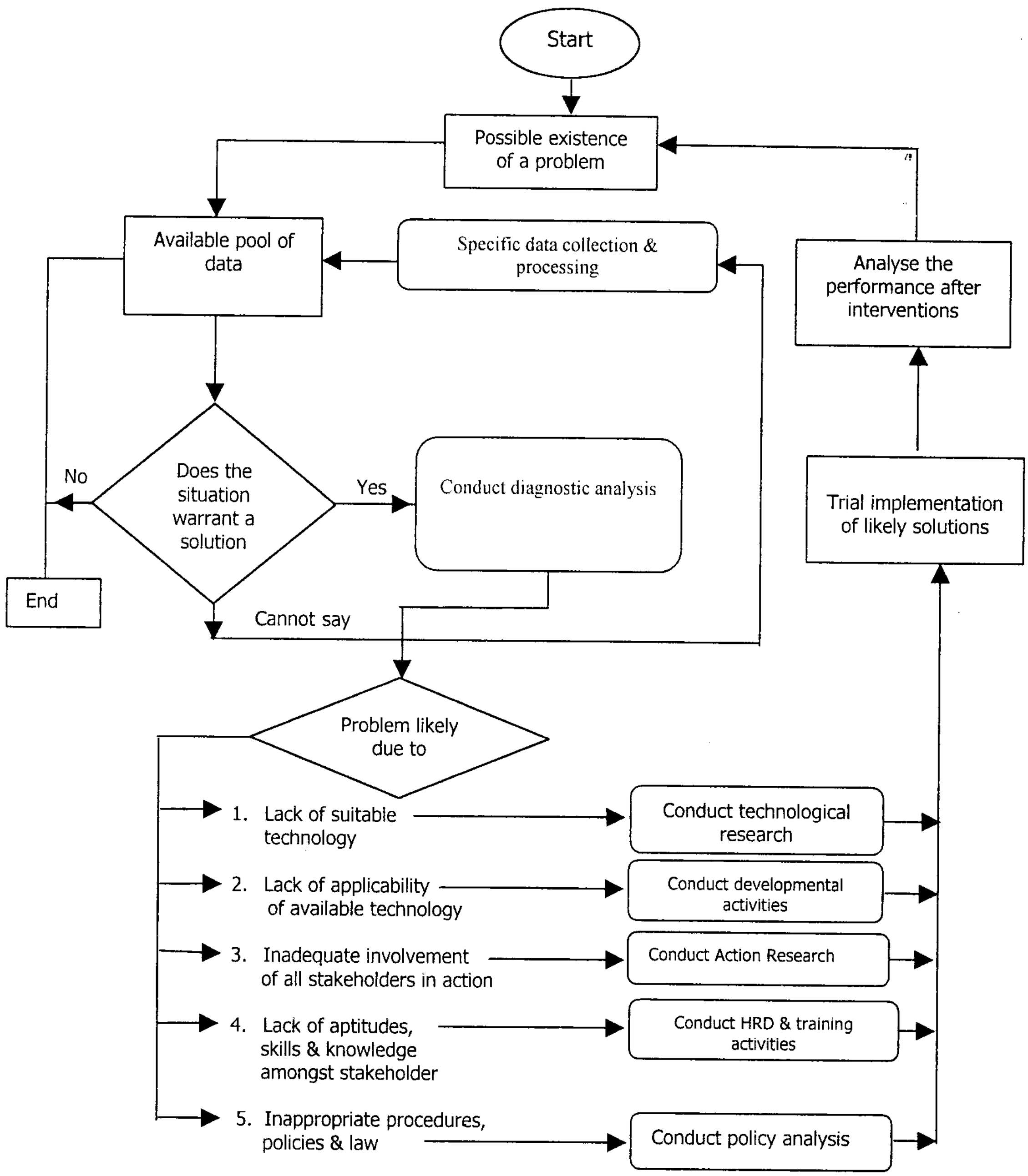
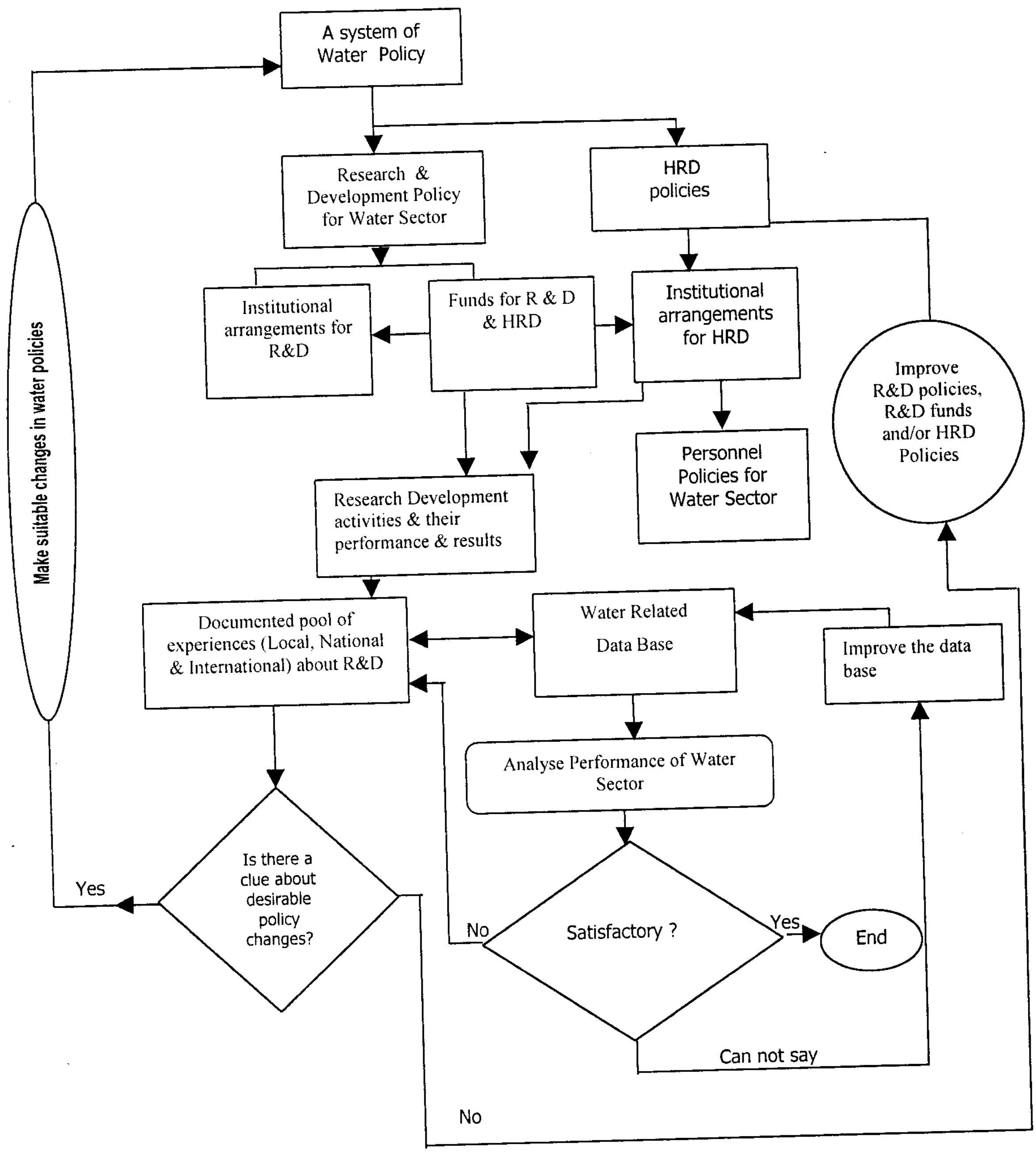


Fig.13.2: Importance of Research & Development and Data Base in Policy Evolution in Water Sector



The institutional arrangement for R&D and HRD, the availability of funds, the personnel policies, a well-maintained database and a well documented pool of R&D experts are the essential pre-requisites for an R&D programme. Further, the programme should include policy analysis and research, HRD and training activities and action research as essential tools.

13.2 The Present Set up

Water sector in India is largely under Government control and private sector involvement in the sector is relatively small and is confined to activities like ground water drilling and exploitation, water supply, water purification system, sewage treatment systems etc. Most of the research and development activities at present are funded by the Government and are undertaken in central or state government institutions. Several academic institutions have also played a significant role. Private institutions like professional societies, NGOs and commercial consultants, also sometimes undertake research and development activities through channelized public funds, but these form relatively a small part of the total effort.

Institutes under the Ministry of Water Resources and under ICAR in the Ministry of Agriculture in the Central Government and the Departments of Water Resources/Irrigation/Command Area Development and the attached institutes in the state governments are the major contributors to the sector. Other Central Ministries having some concern with water developments like the Ministry of Urban Affairs and Employment, Ministry of Rural Areas and Employment, Ministry of Surface Transport (in regard to navigation) and their corresponding counterpart departments in the States do not appear to have institutions specifically for water related research. The National Environmental Engineering Research Institute under Central Government and other institutes conduct important water related research concerning health and environment. Similarly, in regard to inland fisheries, the Ministry of Agriculture has a dedicated research institute and a few water resources projects have research facilities in their fish breeding centres.

Some of the main R&D institutes of the Central Ministries are listed below:

S. No.	Name of the Institute	Controlling Ministry	Main areas of Research
1.	Central Water & Power Research Station, Pune.	MOWR	Hydraulic research including research related to navigation, coastal works and instrumentation.
2.	Central Soil & Materials Research Station, New Delhi.	MOWR	Research related to construction materials, concrete technology, water quality, Geo-physics, Rock mechanics, Soil mechanics and Rockfill testing technology.
3.	National Institute of Hydrology, Roorkee.	MOWR	Studies related to hydrology and environment aspects.
4.	Rajiv Gandhi National Ground Water Training and Research Institute, Raipur	MOWR	Research related to ground water assessment and its use.
5	Water Technology Centre, Pusa, New Delhi.	MOA & C	Research related to agricultural practices in water management.
6	Water Technology Centre, Bhubaneswar.	MOA & C	Research related to agricultural practices in water management.
7	Central Inland Capture Fisheries Research Institute, Barrackpore.	MOA & C	Research related to development of fisheries.
8	Central Soil and Salinity Research Institute, Karnal.	MOA & C	Research related to salinity and reclamation of saline land.
9	Central Soil Conservation Research & Training Institute, Dehradun (Sub-centres at Chandigarh, Ooty, Bellary, Agra, Vasad, Kota, Koraput, Datia).	MOA & C	Research related to watershed management and soil conservation.
10	National Environmental Engineering Rresearch Institute (Water Resources Divn.), Nagpur	MOEF	Research related to water treatment and river water quality.
11	Snow and Avalanche Study Establishment, Manali	MOD	Research related to assessment of water due to snow melting.
12	Central Arid Zone Research Institute, Jodhpur.	MOA & C	Research related to agricultural practices in arid areas.
13	Dryland Agriculture Institute, Hyderabad.	MOA & C	Research related to agricultural practices in dryland.

A number of agricultural universities also conduct research on water management. Funds are funnelled to these universities through the coordinated water management projects by the Indian

Council of Agriculture Research. Engineering universities also do considerable water related research either through their own funds or through sponsored projects. The Anna University, Chennai, the Roorkee University, Indian Institutes of Technology, Indian Institute of Sciences, Bangalore, the Patna University and many others do notable research in water related problems. Similarly, the National Remote Sensing Agency has a water resources division dedicated to remote sensing applications to water resources.

In the state governments, water related research is done mainly through Irrigation Research Institutes/River Research Institutes which were established on the pattern of Central Water and Power Research Station, Pune. These institutes are at different stages of development. In particular, the U.P. Irrigation Research Institute, Roorkee; Irrigation and Power Research Institute, Punjab, Amritsar, the Gujarat Engineering Research Institute, Vadodara, Karnataka Engineering Research Institute, K.R. Sagar and Hydraulic Research Laboratory, Poondy (Tamil Nadu) are conducting noteworthy research. Apart from these, twelve Water and Land Management Institutes (WALMIs) / Irrigation Management and Training Institutes (IMTI) have also been set up. Among the existing WALMIs, those at Aurangabad (Maharashtra), Anand (Gujarat) and IMTI, Trichi (Tamil Nadu) and the Centre for Water and Management Research, Calicut, have been more active in conducting multi-disciplinary research on irrigation management with focus on action research.

Apart from research and development, public funds are also channelised for sponsoring and coordinating research in water sector through established institutions. The main agencies involved in this activity are Indian National Committees such as, those for Hydraulic Research, Hydrology, Irrigation and Drainage, Concrete Structures and Geo-technical Engineering. Organisations like Central Board for Irrigation and Power, Central Ground Water Board, Central Water Commission and National Institute of Hydrology also sponsor and fund research.

The Department of Science and Technology also sponsors research projects in water related fields.

Provision of R & D is generally made at the rate of one percent of the proposed outlay for on-going projects. The total outlay proposed in Ninth Plan is Rs. 136 crores. While the research needs are many, experience so far is that allotted funds are not utilised fully due to limited focus, lack of a research agenda, delays in agreeing to proposals and lack of sufficient number of proposals. This situation has to be changed.

13.3 R&D Achievements

The existing research and development programmes in India have been able to address many major concerns and issues in water sector. Almost all major projects have utilized the services of the research stations, in particular, in regard to hydraulic research and hydraulic model tests. The Central Water & Power Research Station is one of the world's largest institutes in this area. Similarly, all projects and Water Resources Departments are utilising the research and testing facilities available with the Central Soil and Materials Research Station, Central Water and Power Research Station, State Irrigation Research institutes, project quality control laboratories specially set up for routine testing, and facilities available with the Engineering Institutes and Universities.

While meeting the needs of project construction and development fairly satisfactorily, in a larger perspective, India has not contributed adequately to developments in the water sector technologies at a global level. There have, however, been a few notable exceptions. The research and development work on hydraulic analysis of barrages on permeable foundations conducted by Khosla and his team, design of unlined channels in alluvial soils by Kennedy, Lacey and several other irrigation engineers have found international acceptability. Certain gate designs evolved by Visvesvaraya and his team found acceptability but have since fallen into disuse. The Volute Syphon design by Karnataka Engineers was an important step in the development of shaft spillways which have got international acceptability particularly for earth and rockfill dams. Local solutions suited to Indian social milieu in regard to irrigation, water management such as Warabandi of the north west, Kudi marammat system of Tamil Nadu, phad and block irrigation of Maharashtra are important innovations. A system of oxidation ponds for sewage treatment and fisheries development as experimented in Calcutta is another innovation. Certain watershed models developed in Maharashtra, Rajasthan, Madya Pradesh, Punjab etc. are again worthwhile local innovations. However, as in other areas of science and technology, the overall Indian contribution by innovations, developments and research is not in keeping with Indian position as the largest user of water. This is mainly due to the fact that Indian engineers and scientists in the sector were busy tackling day to day problems arising in the construction and operation of projects and consequently concentrated more on developing indigenous technology such as stone masonry in dam construction and assimilating and adopting technologies with respect to concrete making, design procedures of high concrete and embankment dams and ancillary works.

India has a large water sector and also has a large and varied experience extending almost over a century in designing, executing and operating water projects. The country also has a large body of scientists and engineers in this area. Perhaps it is now time to make a bigger thrust in research and development, consolidating the past experience and innovation and building upon them to further develop technologies and systems which would address our own future concerns and contribute to the world body of knowledge and technology as well.

13.4 The Data Base

It is necessary to build systematically a body of data and information system, scientific in approach and comprehensive in coverage simultaneously with a system of data exchange and information dissemination in order to address our concerns in the water sector effectively through research and development.

The existing data collection mechanism in the country consists of :

- Rainfall and climatic data collected by India Meteorological Department.
- Hydrological data pertaining to river flow, sediment, land and water quality collected by CWC and state governments.
- Utilisation of surface water for irrigation collected by Irrigation/Water Resources Departments of State Governments; utilisation of ground water for irrigation use collected by CGWB and State Ground Water Boards.
- Ground Water levels and quality collected by CGWB & State Governments.
- Utilisation of water for domestic, industrial and other uses collected by Local Self Government / Public Health Departments.
- Land use statistics compiled by Ministry of Agriculture.

- Statistics related to Minor Irrigation schemes collected by individual states and compiled by Ministry of Water Resources (MOWR). Similarly, statistics related to command area development collected by State Command Area Development Authorities and compiled by Command Area Development Wing of Ministry of Water Resources.

- Water quality data collected by Central and State Pollution Control Boards besides CWC and CGWB.

In case of hydrological data, the practices and procedures followed by CWC and State organisations are not uniform. Timely documentation of available data is a serious handicap. Existing net work in some of the river basins is inadequate. The professional staff lack motivation in data collection work. There is a general feeling that this work is not recognised and as such the field staff prefer to work on construction projects. Lack of funds as well as suitable man power and hi-tech equipment are some of the other hurdles. This situation needs to be rectified.

Under the World Bank assisted Hydrology Project, the data collection mechanism is being strengthened for surface and ground water(quality and quantity) as well as in the meteorological sector in the Centre and eight peninsular states, namely Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Madhya Pradesh, Maharashtra, Gujarat and Orissa. Similar arrangements have to be made in other states.

Major consumption of water in most of the river basins is in irrigation. Unfortunately most of the state governments do not maintain reliable and systematic records. In many cases the utilisaton figures are not available and varying assumptions have to be made to estimate the quantities of utilised water. The data regarding ground water use is also not properly maintained which sometimes results in double counting of use of surface as well as ground water on the same land. There is large variation in the data on gross irrigated areas, provided by the Irrigation Departments and those, reported by the Ministry of Agriculture. In case of ground water utilisation, data based on volumetric assessment is not compatible with that based on area irrigated, the former being considerably lower. A number of Committees/Working Groups were constituted in the past to deliberate upon the issues involved, but the matter remains unsettled. To overcome the problem, it is necessary to develop proper mechanism for consultation and interface between the various agencies to ensure common lines of data flow from both the Ministry of Agriculture and Ministry of Water Resources.

State and National Data Centres for storage, retrieval and dissemination of hydrological data may have to be set up. Facility for efficient handling of voluminous data requires specific hydrological data management . The institutional and technical capabilities of the Central and State organisations to measure, analyse, disseminate and use the required data need to be strengthened.

The secrecy maintained about water resources data for some of the basins is not only highly detrimental but is also counter productive. Hydrological data of all the basins needs to be made available to the public on demand. In fact, continuously updated data should be published periodically and made available to water planners, economists, administrators, scholars, and other interested members of the public.

The MOWR circulated a draft bill (The Rivers and River Valleys Statistics bill) to provide for collection of statistics for regulation and development of rivers/streams and river valleys. The present position of the bill and views of the Commission on the bill are covered in the Chapter 8 "Legal and Institutional Framework".

The existing scope of data collection as given earlier, is quite comprehensive, However, the spread, reliability and accuracy of the information collected needs to be upgraded.

13.5 Research Needs

Water is a crucial component of the environment and factor of production in the economic system. Sustainable development of the developing countries requires rapid economic development with equal emphasis on environmental conservation. They are not antagonistic requirements but are equally important and mutually compatible. Food self sufficiency is necessary but not sufficient condition of sustainable development. What is important is the most productive use of water with minimum environmental perturbation. While the focus will be on water, it is important that other criteria of sustainable development, particularly conservation of land and natural vegetation, are also ensured. One way to ensure rapid sustainable development is to attempt highest standards of scientific activity in each field, and particularly in water resources development, which has to be undertaken in India at the largest scale with a view to ensure optimal utilisation of the full resource.

Some of the studies required to be undertaken are given below. However, as discussed later, these suggestions are only indicative and have to be revised from time to time according to emerging needs.

Sustainable Development of Water

New concepts are being evolved about development of water in the context of sustainable development. At the outset, the work carried out in the field should be studied and the basic concepts, objectives, evaluation criteria and development approach should be suitably modified. It is imperative that the studies be backed by computer oriented decision support systems in view of uncertainties, non-linear interlinkages and differences about valuations.

Water Availability

The starting point of study becomes an assessment of water availability. This, however, requires representation of the hydrological cycle and its quantification. This includes impact of human interventions and embraces both quantity and quality specification. Two issues may be emphasised. Water is a unitary vector and though it may be perceived in terms of surface and groundwater, for development and management purposes, they are part of the same entity and process. Secondly, consideration of interaction with land is very important, both for development of water resources and management of the environmental state of the land.

Some issues in this context may be further mentioned. One is the assessment of groundwater and its interlinkage with surface water, as adopted currently. The present figures are rather adhoc and cannot form a basis for scientific water developmental planning.

Considerable work has been done regarding surface water availability but as the studies themselves indicate, further refinement is warranted through the modelling of the hydrological cycle. One issue that may be mentioned is further analysis of contribution from snowmelt and glaciers, which is particularly important in the Himalayan rivers.

One of the important components to be studied is assessment of the return flows. The current figures are not really dependable. This will have to be closely related to demand analysis and management as discussed later.

Study of sustainable development emphasises long term perspective. This makes it imperative that study of climatic change on the hydrological cycle should also be undertaken. There is considerable uncertainty about the subject but that makes the study all the more important.

Desalination of saline and sea water is a relatively high cost alternative, normally employed as a last resort. However, in arid areas near the sea coast it may be competitive with tanker supply and may prove viable. Continuous improvements in membrane technology are bringing down the costs, and research needs to be continued in this area.

Augmentation of Supplies

Promoting water infiltration and reducing soil erosion by watershed treatment are essential means of sustained water availability and productivity of land. Ground water recharge by ponds, recharge wells and through unlined kharif irrigation channels can appreciably enhance the supply of ground water. Rainwater harvesting and watershed development will also help to augment utilisable water resources. Similarly, increasing attention is being drawn and needs to be given to revival of traditional systems of water harvesting and storage. Each of them has to be studied in detail. All these have to be investigated and research is needed in respect of theory, local application, adaptation and upgradation.

Water Demand

Estimation of water demand and its implications on water quantity and quality is extremely important. Related to it is the management of water demand, through technology, policy and specifications. We regret to state that the subject has been dealt rather inadequately, so far. For planning purposes, much refinement in the assessment of water demand is needed, even though there has been considerable work on the subject.

Agriculture is the dominant demand and it will continue to predominate for a long time. However, there is considerable scope for its rationalization and optimisation, which also has a very positive impact on reduction of environmental degradation. This is not an issue of technology alone but involves policy and management, which is integral to water resources development.

The present productivity per unit of water in India is considerably less than optimal. Within the country also there is large variation from basin to basin. There is scope for considerable improvement in productivity and consequent reduction in the demand for water. Conservation of water on the field can be achieved by applying the right quantity at the right time and using the right cultivation and irrigation practices. Thus shallow ploughing and mulching can help in conserving soil moisture. Border and furrow irrigation are more efficient than check basin flooding for appropriate crops. Sprinkler and drip irrigation economise in water, though they require silt free water under pressure and capital investment for equipment.

These techniques are not applicable to paddy, which is a major water consuming crop in India. A sizeable proportion of water applied to paddy is lost through deep percolation. This loss can be reduced by puddling. Significant quantity of water can be saved by reducing the depth of ponding to say, 5 cm, during transplanting and critical growth stages, and maintaining soil saturation without ponding at other times.

Research is needed to provide guidance to the farmers suited to their climatic and soil conditions, to obtain maximum production per unit of water for different crops. Crop planning itself has an important bearing on water demand and of course on farmer's income.

Soil nutrient management with a balanced use of organic and chemical fertilisers and nitrogen fixing rhizomes can help in reducing investment as well as pollution. This is a field needing continuous research.

Genetic engineering is now within the reach of practicability. It has been possible to identify genes responsible for special traits, isolate and introduce them into cells of varieties which do not have them naturally so as to produce transgenic material. These traits could pertain to shorter growing season, resistance to pests and viral infections, improved nutritional or flavour characteristics, longer shelf life etc. Though there is difference of opinion about the desirability and extent of practice of genetic engineering, there seems to be little doubt that it will make significant impact on agriculture and water demand in future.

For domestic water supply, research needs to be directed towards the supply of safe water at minimum cost. Evaluation of latest technologies for sedimentation, treatment and purification is needed. For sanitation, the techniques using smaller quantity of water need to be evaluated and improved. For sewage treatment, research effort should be directed towards defining the design parameters for low cost low energy intensive techniques, like oxidation and duckweed ponds. Recycling of treated wastes for industrial use and irrigation has to be promoted, subject to requirements of safety. This is also a field in which research will be rewarding.

Industrial and thermal energy requirements are going to be increasingly important components of demand. They have serious implications for water quality and environmental conservation. The current estimates, both in terms of demand and return flows, are rather adhoc. Considerable work has been done in this area in advanced countries which will have to be adapted to our conditions. These demands and return flows can be considerably reduced.

Minimum flows have to be maintained in rivers from environmental considerations of terrestrial water bodies as well as the right of water users on the banks. The issue has not received due attention and will be increasingly important in the context of sustainable development. The quantum of minimum flows so required has to be established. Research is needed on the actual observed impact of existing high dams and other irrigation systems on the environment. Several large reservoirs like Bhakra, Hirakud, Nagarjunasagar etc. have been in existence for many years and by thorough studies, their impact on the environment with respect to river regime, ground water, fauna and flora, human health and quality of life can be evaluated to provide valuable insight for future. Research is also needed to assess the impact of large scale interbasin transfers on donor and donee basins with respect to biology, sociology and economics.

Habitat demand is a small component of the total, but it is important and has bearing on environmental management. It is a priority issue but can well be assured. Besides the issue of unit figures of demand in each area of agriculture, industry and habitat, another important issue is the estimate of the demand in the long term. The demand is related to economic development and population growth, both of which, in a way are interrelated and are related to environmental management. Several approaches to deal with this complex non-linear dynamic economic-environmental system have been developed, which need to be adopted and improved.

13.6 River Basin System Studies

With the definition of objectives, evaluation criteria, supply and demand estimates and system studies need to be conducted for each river basin to determine the sustainable development policy.

The system studies shall be required to be undertaken in two phases. One is the simulation of the current state of the system including present storages. A valid question is as to how the current use of water as a factor of production is so inefficient, which has implications on economic and environmental performance. This has both technological and management implications, which as we have emphasised, are integral issues. Next, based on this simulated decision support system, is the evaluation of policy of development, demand management and environmental conservation. Water resource development is closely related to development of power. Conjunctive water and power sector development planning is important. Much work has to be done in this field also. The river basins are large and will have to be suitably disaggregated. There are also several objectives. Therefore, a multi-level multi-objective hierarchical analysis followed by simulation studies appears to be indicated.

13.7 Climate Change and Water

The subject has been mentioned under issues to be taken into account while determining the development policy but in view of the uncertainty of the subject, considerable research is required. This also raises the issue as to how uncertainty has to be handled in decision making. The subject needs considerable research.

13.8 Socio-economic and Other Management Aspects

More research effort needs to be directed towards legal and socio-economic aspects of irrigation and water resource development and management in general. The impact on income, employment and acquisition of household goods needs to be evaluated. The equity aspect is also important; do the disparities in income really increase in an irrigated area as has been stated by some social scientists? How are the thorny questions of rights on ground water to be resolved ? The impact on the work load and status of women of farming families and the changes in their quality of life also need to be investigated.

The system of operation and management, particularly of large canal systems, is capable of considerable improvement. Participatory Irrigation Management is receiving increasing attention and varied experiments and experience in the country have to be studied on a continuous basis, for successful extension to all areas.

13.9 Technological Innovations

As engineering technology advances, many problems get resolved, yet there are several fields which need further research to resolve problems being faced at present or which may arise in future. Some of the more urgent areas needing research work are listed below. These are indicative and are not meant to be exhaustive.

- Hydraulic roughness of sediment transporting channels subject to changing bed formations.
- Siltation of estuaries and the quantum of flow or other measures needed to flush them.
- The impact of flood control marginal embankments on river regime, the possibility of aggradation, drainage congestion on the land side of the embankments.

- River control and management, prevention of bank erosion, hydraulics of alluvial rivers, mechanics of meandering.
- Various techniques for prevention and relief of water logging, reclamation of saline lands.
- Forest hydrology – impact of tree cover on peak flows, low season flows.
- Design of less costly sedimentation chambers for hydro stations.
- Evaluation of plunge pools cascades ramps with friction elements for energy dissipation.
- Evaluation of three-dimensional seepage under relatively narrow long structures.
- Three dimensional dynamic analysis for rigid and embankment dams for earthquake conditions. Other problems which can not be foreseen may emerge while designing a project and will then require specific research effort.
- Evaluation and research on emerging construction technologies and new construction materials.
- Automation in the operation of existing and new canal systems.

13.10 Documentation and Co-ordination of Inter-disciplinary Research

If the results of the research work are not properly documented, they do not become available to other potential users, who may be facing similar problems. It is extremely important that all research results are properly documented and published. The completion reports of important projects would record problems faced and solved and will be highly educative.

Effective networking and co-ordination of research work done in different institutions is essential to maximise their benefit and avoid duplication of effort. Intercommunication between research workers active in the same field and in different disciplines enhances progress of the work and evolution of new policies and systems. The restructured CWC should give special attention to coordinated inter-disciplinary research by drawing up priority research agenda from time to time and funding them. It is not necessary to try to start new institutions. The task can be done by strengthening existing institutions and by farming out and networking of research in institutions of other disciplines.

II. Human Resource Development

13.11 One of the most crucial inputs for deriving maximum sustained benefits from the water resources of the country is trained and motivated manpower. The development of water resources presents one of the most difficult challenges to the technical knowledge and innovative capability of engineers. Water resource planning for optimal and sustainable development requires mastery of the techniques of data analysis, optimisation, economic evaluation as well as environmental impact assessment. Such expertise may be available from engineering as well as social science pools, though their orientation will have to be changed accordingly.

The works to develop water resources include dams, barrages, tunnels, powerhouses, canals, hydraulic structures on the canals, and the distribution systems, etc. The planning and design of such works requires specilised knowledge of hydrology, soil water plant relationship, hydraulics, structural engineering, foundation engineering, rock mechanics, plant design, power engineering etc. In fact, there are few aspects of the engineering field which remain untouched. The problems which actually arise on projects stretch to the maximum extent the theoretical knowledge as well as experience of the best available talent. Similarly, the magnitude and complexity of construction problems is hardly equalled by any other category of works. After construction, management presents its own operational problems, supplemented by agricultural and social aspects.

Ground water development and management has its own set of problems. Evidently, only the best available talent equipped with the best possible education and training can cope up with complex problems involved in the development of water resources.

13.12 Technical Education

Since independence, there has been a rapid expansion of technical education. The post-graduation and doctoral level education which was practically non-existent before independence has been well established. There is, of course, considerable variation in the quality of education at different institutions. It would not be entirely correct to classify institutions according to the prestige assigned to them or even the resources made available to them by the Government. There may be a dedicated and talented group of faculty members in a particular specialisation at a small college, doing better work with their limited resources, than that being done at lavishly endowed institutions. However, in so far as prestige attracts brighter students, it tends to become self perpetuating.

Because of the slow rate of economic growth and dismal employment scenario, engineering is one of the coveted fields for university or college entrants. Admission are generally made on basis of competitive entrance examinations.

In the process of rapid expansion of engineering education, some rather low quality institution have come up. The universities, weak, harassed and not free from internal and external pressures, compromise at successively lower levels, both in respect of recognition and examination standards. The low quality engineering graduates, whether from the private or state institutions will further burden the system and result in even more rapid deterioration in the execution and management of engineering projects.

India has still a long way to go in developing its infrastructure whether in the field of transport, development of water resources for irrigation and power, domestic and industrial water supply and sanitation, housing and commercial building etc. Greater agriculture productivity and industrial development are not possible without rapid expansion of infrastructural facilities. The Civil Engineer who gets into water resources area should have gained sufficient knowledge of fluid mechanics and hydraulics, hydrology, hydraulic structures and also been given courses in irrigation and drainage, hydro-power, water supply etc. He should also be introduced to pollution control, environmental and socio-economic issues associated with water resource development.

Post graduate courses in engineering were started in the country almost forty years ago, and have now come of age. Master's level courses in water resources area are now offered by a large number of institutions, and many of them, though not all, maintain requisite standards. Some institutions emphasise hydrology and system planning, others fluid mechanics and hydraulic problems and a few concentrate on design problems. There are only a few courses on water use management. A major problem at post-graduate level is that of motivation ; while specialisation in structural engineering or soil mechanics and foundation engineering can be useful in any branch of the profession, training in water resources area will be practically redundant unless the student ultimately finds employment in this field. The post graduate students who are motivated to take maximum interest in their studies are those already committed to a career in Water Resources Area, that is, in – service engineers who have served for a few years and then join post-graduate courses on either being sponsored by their employers or on their own to meet a felt need.

13.13 Development of Personnel

Personnel involved in water sector include public servants, persons in private sector industries involved in construction, water treatment etc, NGOs and the end users like farmers.

Now, as also in the future, the larger groups involved will be public servants and water users. In future, the relative importance of the role of government organisatons, NGOs and users in managing the water sector would undergo change. An indication of the likely change is given below :

Responsibilities for Water Sector Functions by Organizations

Area	Central and State Governments	Private Sector	NGOs and Water Users	Professional Groups and Societies
Policy formulation	YY ZZ		Y ZZ	Y ZZ
Planning, resources assessment and sectoral reviews	YY ZZ	Z	Z	ZZ
Consultancy and designs	YY Z	Y ZZ		Z
Financing	YY ZZ	ZZ	Z	
Project construction, Large works	Y	YY ZZ	Z	
Construction and operation of small irrigation works	Y	Z	ZZ	
Research and development	YY ZZ	Y Z	Z	Y Z
Training	YY Z	Y Z	ZZ	Y ZZ

Key : YY = major responsibility at present ; Y=some responsibility at present; ZZ= major responsibility envisaged in future; Z= some responsibility envisaged in future.

The enormity of the problem can be judged from the large number of persons involved. The departmental personnel involved in irrigation management alone have been estimated to be around 3,00,000. In addition, persons involved in construction of facilities and in water supply and other sectors are to be considered and the number of users is very high.

The training of water users for municipal supplies has to be in the nature of general public awareness. Farmers, because of their large numbers, would require special training through farm leaders and NGOs, who themselves may have to be trained through WALMIS, CADAs etc. Agricultural Universities should also play an active role in the training of farmers.

The training needs for persons in the industries would have to be taken care of mainly by their own training institutes. Governmental procedures and, if necessary, the laws (in regard to compulsory use of licensed personnel) can be moulded to ensure that contracts for construction or operation of water related facilities are conditioned on engagement of persons with prescribed training.

There are many weaknesses in human resources management in the public sector, as discussed below :

The most important and urgent requirement is with respect to recruitment. It is essential that recruitment should be basically merit based, and should be made regularly and systematically after a proper assessment of requirements.

As stated in chapter-8, the overall weakness of the present Government organisations is their hierarchical rather than functional structure. In this structure, there are many layers of top-heavy bureaucracy with many entities reporting to the Engineer-in-Chief/CE and the Secretary (Water). Lack of due importance to professional and functional aspects tends to blur responsibility, inhibits specialization and fails to give needed organizational focus. The water managers in the public sector seem to be working not towards professional excellence but towards power and budget size. Long terms goals get linked to obtaining preferred transfers, posting and promotions.

In line with other government departments, the tendency is to follow the correct rules and procedures, to the satisfaction of the Department. The satisfaction of the users through optimum use of water and management of water towards their satisfaction are not fully attended to.

Even though most water related issues involve multiple disciplines, the working of the water sector is neither multidisciplinary, nor inter-disciplinary. The fragmentation of water related institutions by disciplines inhibits teamwork and does not provide inter-disciplinary environment. It is necessary that all professionals involved in management of water resources be trained in the different disciplines involved that is agriculture, soil science, sociological and economic aspects. Interaction with users and other sister organisations needs a human relations approach, which can be acquired by example as well as by training.

The links between academic institutions and water sector personnel are rather poor. This keeps the academicians away from important practical problems and issues and does not bring the latest technologies to the water managers. Even when such links exist, they involve consultancies and not joint working.

13.14 Possible Action Plan for Professional Development

Branches like design and construction planning, irrigation management and hydrology need to be nurtured as separate specialisations. While a young professional should rotate among different areas to get familiar with the entire scope of work in the Department, he should ultimately be enabled to specialize in a particular aspect and placement policies should ensure this.

Most of the big states have got institutions for research such as Irrigation Research Institutes and WALMIs. These need to be made autonomous organisations in order to ensure the continuity of the persons and to give them flexibility in their functions.

In order to encourage water sector personnel to improve their knowledge and skill even without formal attendance and thus obtaining career advancement, a flexible scheme of obtaining a prescribed number of credits through a number of elected courses by correspondence could be put in place, with the co-operation of academic institutions.

A regular personnel training policy needs to be evolved by each Government and Organisation. This policy needs to provide for adequate training, with emphasis on acquisition of knowledge in the early career, on acquisition of skills in the middle period and on managerial aspects in the later period. On the average, a professional needs to receive on-the-job and regular training, for a period of one to three years depending on the nature of his responsibility. Senior and middle level professionals need to acquire skills in communication, conflict resolution, negotiations, leadership and interdisciplinary coordination to discharge their responsibilities.

Water resources departments in the states need to create training Institutions for induction training and refresher courses for all aspects including construction, planning, designs and legal, sociological and environmental issues. In regard to training in irrigation management, facilities created through WALMIs need to be used. These state specific facilities would take care of the routine and repetitive training needs. In addition, there would be specialized training needs, where the number of persons to be trained in any one state would be small. The National Water Academy being set up by CWC at Pune may cater to such specialized needs. Specialized research institutes and academic institutes should be involved in the training programmes. By using information technology and multimedia, many interactive training courses can be prepared to enable a person to learn on his own.

For postings which allow professional development, such as those in design, planning, research institutes, training could be made mandatory. Some state governments have prescribed, in their rules, such postings as essential requirements for promotion at specified levels. This seems to be an effective tool.

Persons need to be encouraged to obtain higher academic qualifications through study leave provisions. Persons with higher qualifications and exceptional performance should get faster promotions.

The officers working in the research stations may be encouraged to take up consultancy works on water related subjects and research projects sponsored by the government or other agencies to give opportunity for professional development. They should be allowed to receive a share of the consultancy fees.

In technical and professional cadres, the hierarchical levels need to be reduced. With large delegation of powers to the project managers, system managers etc., it should be possible to have a flat top structure beyond these levels. Longer duration grades and lesser number of levels could be prescribed. Promotions need not be of a purely routine nature, but need to take into account merit, as reflected in performance and user satisfaction, acquisition of training and professional contributions along with years of experience. There is a need for much larger horizontal mobility, within a specialization, amongst cadres and specialists. For example, a hydrologist or project planner in Uttar Pradesh could much benefit if he could work on secondment in Maharashtra, in the National Water Development Agency and so on. Similarly, exchange between academic institutes and line department personnel would be beneficial and service rules should enable this, ensuring equality of benefits.

Fast track promotions either through competitive examination or other appropriate transparent selection procedures are necessary to ensure a level of responsibility appropriate at a particular age. A person stagnating in a junior position for half his service can hardly be expected to retain initiative or enthusiasm.

Public services need to be transparent in regard to their important professional outputs. Designs, planning and operation manuals need to be opened to scrutiny of experts outside the concerned departments. Academicians and experts from other cadres could be consulted. While

Technical Advisory Committees are presently available for only a few projects, it would be desirable to bring all professional outputs under the purview of such bodies.

Regular reviews of the satisfaction levels of the water professionals need to be made. If they are involved in designing better procedures by removing irritants, satisfaction levels can be improved without large additional costs.

For the training and research personnel in the water sector, the 'in situ' career advancement without change of job or responsibilities has to be provided for, on the basis of proper evaluation of performance.

Water professionals, at senior levels, could be given a choice : They can either branch into senior management and policy making responsibilities or could continue in their specialised fields striving for professional excellence and towards becoming a role model to the younger generation. Both the choices need to be equally attractive financially. Such a move could go a long way in changing the prevailing attitudes about co-ordination, management, administration and policy making to a healthy and superior level.

CHAPTER - 14

TOWARDS SUSTAINABLE DEVELOPMENT

As we stand today as a nation, at the turn of the century, looking back at our progress and contemplating the future, we may derive some satisfaction from the path traversed, particularly during the half century after Independence. But the challenges we shall be facing in the future are many. There is the challenge of feeding a growing population. We have grown from a nation of 360 million in the middle of the twentieth century to a nation of one billion today. On present indications, we may reach a size of around 1.5 billion by the middle of the twentyfirst century. There is the challenge of poverty. Over 35 percent of the people are still poor and undernourished. After showing a fast decline during the eighties, the poverty proportions have become somewhat sticky during the nineties with the implication that the absolute number of poor is increasing. There is the challenge of meeting growing aspirations for higher incomes and better life of an increasingly more informed people. There is the challenge of meeting the aspirations of growth in a way that development is sustainable and the growth processes do not destroy the delicately balanced environmental and ecological systems. At the core of all this is the challenge of meeting the water needs of the society.

Though water as an element is abundant on Earth, the pool of annually renewable fresh water is limited and is becoming increasingly scarce relative to needs. The total surface water resources in India are roughly four percent of the World's fresh water resources, whereas the country's population is 16 percent of the World's population. We have estimated the total annual water resources of India to be 1,953 Km^{3}. This includes 432 km^3 of water available from ground water sources. However, the utilizable quantities of water drawable from the total annual resource are only 1,086 km^3 which is the sum of 690 km^3 drawable from surface water sources and 396 km^3 drawable from ground water sources. This is exclusive of the return flow resulting from additional irrigation, which will be about 170 km^3.

Withdrawability of water largely depends on the existence or possibility of storage and diversion structures and land availability. There are limits to the creation of such structures due to physiographic conditions, environment considerations, extent of technology and problem of resettlement and rehabilitation. Financial viability of projects for storage and diversion is also a major consideration.

The Commission has estimated that the total water requirements of the country in year 2050 would be about 973 km^3 on the lower side and 1,180 km^3 on the upper side, depending upon actual population growth. These requirements take into account the water needs for drinking and domestic use, needs for agriculture, environmental needs, industrial and power production needs, and navigation. Irrigation is the dominant use and will continue to remain so. The proportion of domestic use of water will grow from about five percent at present to anywhere between nine and ten percent in the next fifty years.

It can be seen from these figures that the availability of water in year 2050 is barely adequate to meet the requirements. It is rather a delicate balance and its realization depends on a number of assumptions and actions. If any of those critical premises/assumptions do not turn out to be correct or the required actions including storage of monsoon waters do not materialize, this delicate balance between requirements and availability of water will be disturbed with serious implications for well being of society. Of course, the projections, both of availability and requirements, are based only on the present state of knowledge and technology.

What is even more important to note is that this critical balance is achieved only at a national scale. National water resources do not form a single pool from which water is easily transportable/transferable to all the points of need. The availability of water is very unevenly distributed over the country. There are regions with harmful abundance and regions with acute scarcity. Floods and droughts cause damages sometimes simultaneously in different parts of the country. Development of local water resources could help in harnessing more utilizable water in regions of scarcity. Revival of local and traditional water storage structures, innovative methods of water harvesting and integrated watershed development are the strategies which the Commission highly recommends in this context.

The task before this Commission was to explore ways of meeting the challenge of balancing future water needs with availability. Water needs have to be met with methods and means that are sustainable over time. Short period solutions do not work in this area. Sustainability has to be ensured both from the point of view of meeting the developmental needs and preserving the eco-systems. The Commission firmly believes that this challenge can be met if we adopt a scientific approach in exploring all the possibilities and objectively evaluating their feasibility and impact from human, technical, economic, social and environmental angles. The Commission has striven to address the problem in this spirit. Ideological attachment to a particular way of doing things will not be helpful in finding acceptable and sustainable solutions, we believe.

We start with examining the needs and availability of water. The needs and availability are, in the first instance, examined independently of each other. Neither follows from the other. It is only later that the issue of convergence between the need and the availability is examined and the conditions of convergence are explored. At the back of our mind the needs again are in two parts. In the first part are those needs which are absolute like the need for drinking water, the minimum needs for domestic use, water needed for food production or maintaining the eco-systems. In respect of these needs certain norms have to be met and they are the first charge on the availability of water. Then there are the needs which are somewhat flexible and where adjustments can take place both in terms of norms and in terms of choice of activities, be it a cropping system or an industrial activity. The second group of needs could be subjected to demand management to a large extent and it needs to be done.

Water conservation strategies need to be accorded highest priority everywhere. Public awareness, sense of ownership and women's participation have to be adequately encouraged to make water supply programmes more efficient and effective. People's participatory institutions and panchayats and municipal bodies should be increasingly encouraged to shoulder the responsibility of maintaining local water supply systems.

Local water resource development and management would be an important element of the strategy of meeting the water needs of the future particularly in water-scarce regions. There is need to lay emphasis on local water planning, water harvesting at micro level and integrated water shed development. The traditional water storage structures which had gone into disuse need to be revived. This is an area where people's participation is most important. At every stage, the people concerned must be involved in planning, implementation and development of local water resources. The participatory approach to watershed development would involve all individuals in any watershed area in the process of planning a watershed approach and would secure their commitment to execute, monitor and maintain the project even after completion.

In case of water for domestic use, we have noted that at present there are marked differences in urban and rural per capita consumption levels. We have taken the view that over time the urban and rural standards of consumption will have to converge.

In estimating the water requirements for irrigation purposes, we have taken a view that food security based on relative self-sufficiency in food production is a national objective. Projections of irrigation water requirements are also based on an important stipulation of constantly improving irrigation efficiency. Irrigation efficiency is projected to go up from 35-40 percent at present to 60 percent in the year 2050 in the case of surface water irrigation, and from 65-70 percent at present to 75 percent in the case of ground water irrigation.

Irrigation water management needs to be improved to raise overall irrigation efficiency, reduce costs and to see that creative potentials of irrigation are realized in practice. Formation of farmers' organisations and transfer of irrigation management to them are important in this regard. The cropping systems adopted and the agriculture practices should be in tune with the local water availability situation taking into account the soil type, the drainage and other ecological factors. Available water should be allocated according to assigned priority of use. Every care needs to be taken to see that the irrigation system does not cause damage to the local environment and eco-system. Particular attention needs to be paid to the maintenance of irrigation systems. The older systems have deteriorated for want of proper and adequate maintenance.

Energy is crucial to economic growth. India has a hydroelectric potential of about 84,000 MW at 60 percent load factor. So far, only 15 percent of that has been utilised. Further development of hydropower needs to be given high priority.

We need to evolve efficient strategies for coping with floods. While it is possible to moderate the floods in certain situations to protect the habitats from the ravages of floods by embankments etc., in the long run our approach to floods has to be guided by the fact that the floods are not entirely avoidable. Experience has shown that damages from floods in recent times have gone up more because of man-made causes like encroachment in the flood zones. Encroachments in natural depressions have accentuated flood peaks and caused inundation over large areas. Effective measures, with legislative backing, may have to be adopted to prevent blocking or encroachment of drains and filling of depressions and tanks.

Since there are large disparities in the availability of water in different river basins, inter basin transfer of water has been receiving attention. However, it may not be possible to persuade the states to spare water till their own demand is met. In basins with possible surpluses, optimal utilization of land and water has to be aimed at. Thus, only after meeting the essential requirements, if there is surplus water available in the basin, its transfer to other basins may be considered. For deficit basins, the aim would be to meet domestic and industrial demand in full, but to achieve a lower cropping and irrigation intensity than in case of well endowed or surplus basins. The overall approach is that economic development of no part of the country should be constrained by shortage of water. At the same time, the pattern of development could be different in states having adequate water and those to which water may have to be transferred at high cost.

Projects for inter basin transfer of water in substantial quantities over long distances would be outstandingly large and complex. More scientific and engineering exploration and impact studies of such large programmes are required along with necessary institutional changes.

In the context of existing problems and future needs, we need to focus much more on the development of necessary legal and institutional framework. There is also the need to put in place an effective mechanism for centre-state consultations on issues relating to water.

There is an urgent need for enactment of a law on inter-state rivers, in the place of the River Boards Act, which inter-alia may provide for the constitution of River Basin Organisations. This act may also provide for the studies to be made by the Union for possible inter-state inter-basin transfers, so that the work of NWDA has statutory backing and the organization would be able to obtain information and cooperation for the studies.

There is need for institutional arrangements with the requisite legal backing for making the states to come together for holding serious discussions on sharing of waters including diversion to non-basin states, ultimately paving the way for reaching an agreement on the basis of mutual needs. Several innovative ways are possible. One such arrangement could be through mutual discussion and arriving at an agreement by the River Basin Organizations of the respective basins. Efforts for seeking mutual agreement on inter-state water disputes should first be made at the river basin level, through the mechanism of the River Basin Organisation (RBO). Legal and institutional mechanisms are also needed for monitoring exploitation of ground water in all places and for its regulation in 'dark' and 'over exploited' areas, where ground water use needs to be regulated without delay.

We have made detailed recommendations in this respect including recommendations for institutional development at village, state, basin and national levels.

The water sector as a whole suffers from financial inadequacy and mismanagement. The financial inadequacy is largely a consequence of strained public sector resources. Funds going into the sector have shrunk and have been spread over an increasingly large number of projects. It is urged that more attention be paid to this sector in terms of adequate financial allocations under the Plans. Mis-management has developed in the sector over time as water rates do not get revised for long periods and have become inadequate even to cover a fraction of the maintenance costs. With the inadequacy of availability of public funds in general, the maintenance of projects has suffered the most. The situation needs to be remedied urgently. The Commission has made a number of detailed recommendations in this regard. In the urban domestic water supply sector also, our view is that the principle of recovery of 'user charges' should be adopted to the maximum possible extent.

The water sector and particularly the irrigation sector is loaded with a very large number of on-going major projects, which have been under construction for decades. This results in waste of financial, physical and human resources which remain locked for a long time without producing returns. Hence, there is a need to prioritize projects and complete them quickly in order of priority. We have worked out a detailed grading system for projects and recommend that this grading system be adopted to prioritize projects in each state and the release of plan funds by the Planning Commission be based on such prioritisation.

In an era of emerging water shortages, we cannot but look beyond our frontiers in planning for India's water future. The Himalayan Rivers are shared to a very large extent and there is a hydrological unity in them. Ignoring these ground realities can only result in warped national planning that falls short of optimization and maximization of benefits. Regional cooperation in water and energy development offers solutions to many national problems and will speed up both national and regional development with a strong bonding of good neighbourliness and interdependence among the countries for mutual benefit.

An optimized and integrated development of South Asian and Trans-Himalayan river waters calls for cooperation among the countries on data and information sharing and preparation of perspective plans. Trans-Himalayan Rivers have great potential for enhancing water availability and hydropower. International cooperation is required for moderating floods and for using the river systems for navigation. Transparency, public awareness and stakeholder participation are the pathways to future water resource development. This will be more so in respect of trans boundary projects. There is need to develop genuine consensual approaches, and towards this end, to develop new and strengthen the existing mechanism to build up data bank and clearinghouse of information. Capacity building for regional water resource development is also necessary and in this context the role of universities, research institutions and NGOs has to be adequately recognized and promoted.

Integrated management of water resource should be based on the treatment of water as an integral part of the eco-system and as a natural resource whose quality and quantity determines the nature of its utilization. Water use, in turn, has its impact on water quality and therefore utilization of water has to be so managed as not to contribute to the deterioration of water quality.

We have made recommendations in respect of protection of water quality and aquatic water systems, control of surface and ground water pollution, maintaining minimum flows of water in major rivers, assessment of environmental impacts of projects and integrating remedial measures with project implementation. Adoption of 'polluter-pays' principle and standards of resettlement and rehabilitation of displaced persons is also recommended. Water is also related to health issues. The fast growing urbanization, lack of water delivery and sanitation facilities and poor system maintenance are resulting into water contamination and increasing incidence of water related diseases. Improving the quality of drinking water, ensuring proper sewage disposal and providing more water for both personal and domestic hygiene are keys to prevention or control of major diseases.

Water resource development is to be seen not merely as a single-sector-end objective, but as a prime mover in developing larger systems with multiple linkages. This calls for a well set out multi-disciplinary research agenda covering not only technological issues but also issues of social, economic, legal and environmental concerns. A trained, motivated manpower being the backbone of any developmental activity, in the water resources sector also, there is need for human resource development. The kind of approach suggested requires multi-level training of personnel involved in the sector to undertake the challenging tasks ahead.

The challenge in water sector is to simultaneously take care of the needs of development and environmental health and thereby ensure the sustainability of development. The problems are not beyond the present state of knowledge and technology. Given the needed political will and societal awareness, the nation shall be able to meet the challenge.

CHAPTER – 15

SUMMARY OF RECOMMENDATIONS

1. In the earlier chapters, we have dealt with different aspects of water resources development and management. Our studies show that the overall availability and requirement of water for different uses will broadly match each other at the national level but there will be regions of harmful abundance and acute scarcity in the country. Hence, water conservation in every sphere and increase in efficiency of water use in every activity should be overriding considerations in water resource development and management. The methods and means of water resource management should be sustainable over time both from the point of view of development needs and preservation of environment. A resume of the recommendations made in the various chapters is given below :

2. The National Water Policy (1987) needs revision in the context of the many issues and concerns that have gained importance in recent years. It is desirable to go in for a new policy document instead of making additions and amendments. The policy document should be accompanied by a blue print for action.

3. Water Availability and Requirements

3.1 The projections of water availability and requirements have had to be based on a number of assumptions. CWC should take up the work of further refining the assessment of water resources of various basins and collect reliable data pertaining to observed flows, utilisation from surface and ground water resources for irrigation, domestic and industrial uses and evaporation losses. The return flows from irrigation and from other uses from surface as well as ground water resources should be assessed after considering the prevailing irrigation efficiency of the system. More accurate observations on irrigation efficiencies are needed. The State Governments and other relevant Central agencies collecting data should also be associated with these studies. It is desirable that such reassessment is carried out periodically, say once in 5 to 10 years. State-wise assessment of surface water resources would also be desirable as the states are primarily responsible for planning and development of water resources.

3.2 CWC should also carry out studies to revise the estimates of utilisable flows in each river basin/sub-basin/state.

3.3 CGWB should carry out further studies for verification and estimation of various parameters that are being used for assessment of ground water resources and revise the assessment. Since static ground water resource has not been fully investigated, no part of this resource is included in the estimates of utilisable water resources. It is necessary that investigations are completed at the earliest, especially in drought prone areas.

4. Development and Management Issues – Irrigation, Flood Control, Hydro-power and Navigation

Irrigation :

4.1 One of the major criticisms of irrigation schemes is about the large gap between potential created and its utilisation. This gap, which has persisted since long, should be reduced to the minimum. For this, it is essential to define a system for correctly reporting figures of potential and utilisation. Since there is no uniformity in the norms and definitions adopted by different states and by different departments (Irrigation, Revenue and Agriculture) at present, it is necessary to lay down uniform guidelines for reporting the figures of potential and utilisation. Use of satellite imageries should also be made for assessment of irrigated areas. It is suggested that definite guidelines may be laid down for reporting the figures of potential created and the utilisation achieved so that there is uniformity in the figures reported from all the states. The figures of the departments and land use statistics should be reconciled.

4.2 We recommend that the term 'irrigation potential created' by a project at a given time during or after its construction be defined as the aggregate gross area that can be irrigated annually by the quantity of water which could be made available through infrastructure completed upto last government outlet in the water delivery system. We also recommend that the term 'irrigation potential utilised' be defined as the total gross area actually irrigated by a project during the year under consideration.

4.3 There is need for periodical reappraisal of potential of irrigation projects and figures of actual irrigation, in order to take measures to accelerate the utilisation of the potential created and make improvements in utilisation.

4.4 Removal of silt from the reservoirs has been engaging attention since long. A cost effective method of removal of silt has yet to be devised. Desilting of reservoir is project specific. However, research efforts are required for development of economic technologies for the purpose.

4.5 There is need to undertake state-wise assessment of waterlogged and salt affected areas in irrigated command on the basis of uniform criteria. The status of protected and reclaimed land should be reviewed in the fifth year of every five year plan.

4.6 In order that the area under water-logging does not increase, precautional measures have to be taken. In areas affected by water-logging, remedial and ameliorative measures, as suggested, have to be undertaken.

4.7 There is need for a paradigm shift in emphasis towards improving the performance of existing irrigated agriculture. Marginal changes in irrigation practices will not be enough to increase productivity. If a 4 percent growth in irrigated agriculture is to be achieved, efficiency of the existing systems is to be enhanced; water so saved should be utilised to increase irrigation intensity and farming practices improved with modern inputs and technologies. Operation and maintenance have to be substantially improved through participatory management.

4.8 Heavy subsidies in electricity consumed for agriculture have tended to encourage wasteful use of energy and also wasteful use of water. This has also encouraged farmers to overdraw water from deep aquifers, thus causing water quality deterioration in many cases. The subsidies have also adversely affected the financial conditions of the State Electricity Boards. It is, therefore, necessary to gradually reduce the subsidy on power for agriculture.

4.9 Irrigation operators should educate farmers with pilot experiments and demonstration plots, in respect of the advantages of less than optimal consumption of water. Every State Government should make whole-hearted efforts in introducing Warabandi system including night irrigation.

4.10 After each modernisation project is completed, a performance review should be carried out, which should assess the benefits and costs. Such a review should be carried out for all modernisation projects which have so far been completed. For new projects to be taken up under this programme, technologies and reforms, as suggested, should be included as components of the project.

4.11 Canal automation is a new technology, which is being introduced in some projects in our country. We do not have experience of its performance under the management practices adopted in our country. Therefore, performance requires to be watched carefully and the modifications, if any, to be incorporated in the future canal automation project identified. The approach should be somewhat cautious before large-scale programmes are taken up.

4.12 Re-use is an important method of managing drainage water. The options for re-use of drainage water would include direct use for irrigation, blending with canal water, cyclic or rotational use, saline agriculture, forestry system and solar evaporators, aquaculture and use of saline water through salt tolerant crops

Flood Control and Flood Management :

4.13 Although it is feasible in most cases to provide a certain degree of protection against floods in terms of reduced frequency and flood damages, there are no universal solutions which can provide complete protection against floods. The country has, therefore, to shift its strategy towards efficient management of flood plains, flood proofing including disaster preparedness and response planning and flood forecasting and warning and other non-structural measures such as disaster relief, flood fighting including public health measures and flood insurance.

4.14 Embankments do provide reasonable protection. However, it is recommended that performance review of selected embankments may be carried out and based on the findings, planning, designs and management of embankments may be reviewed for obtaining better results. It is essential to associate the beneficiaries in the upkeep and surveillance of embankments during the monsoon season for prevention of possible breaching.

4.15 The network of flood forecasting and warning at the Central level needs to be extended to remaining flood prone areas.

Hydropower :

4.16 There is an urgent need to evolve suitable strategies for accelerating the pace of hydro development. In north-eastern region and Jammu and Kashmir where there is large hydro potential but the transmission costs to consuming centres are high, energy intensive industries could be located close to the hydro project sites. This would attract private participation and accelerate hydro-power development. The other measures suggested for the purpose may be classified broadly in two parts; the first as a short term strategy and the second as a long term strategy. The short term measures include – full financial support to public sector on-going schemes, thorough survey and investigations and preparation of DPRs strictly in accordance with norms, effective monitoring, sorting out implementation problems where necessary, completion of renovation, modernisation and uprating of old plants and small hydro development. The long term strategies include creation of hydro development fund, expediting the hydro potential review in consonance with environmental concerns and resolution of inter-state disputes in case of attractive projects, promotion of joint ventures, tariff rationalisation, attractive R & R policy etc.

Navigation :

4.17 The inherent advantages of lower operation costs, fuel conservation and comparative safety of operations in inland water transportation can be availed of only by systematic policy measures.

4.18 Development of inland water transport needs basic infrastructure like the fairway, terminals and navigational aids. It is unlikely that the private sector would come forward at this stage to make such investments. Government should undertake the development initially.

4.19 Inland Water Transport (IWT) should be treated as a nascent industry as recommended by the Steering Committee on Transport Planning (1988), as some waterways may not be financially viable in the initial period. Water front development programmes and rebates for investments are necessary to bring traffic generating activity back to the rivers.

5. Domestic, Industrial and other Uses

Domestic Uses :

5.1 Ideally, water supply and liquid waste management schemes should be integrated and for this, it is necessary that water supply programmes are not taken up without simultaneous approval of sanitation/waste water disposal programmes.

5.2 The norms adopted for satisfying the basic human needs of communities (both urban and rural) may be reviewed after every 10 years.

5.3 The assigned target of 100 percent coverage in water supply can be achieved only if impediments like inadequacy of funds are removed and an autonomous system with economic viability is encouraged. The latter has a direct impact on the generation of funds for maintenance and development.

5.4 To reduce the gap between demand and supply, water conservation measures be accorded highest priority, specially in areas facing water quality and scarcity problems, with emphasis on recycling/reuse of treated waste water for non-domestic uses.

5.5 Poor maintenance of the systems by the utilities results in leakage of costly treated waters. The discipline of maintenance should be instilled in the utilities and they should be held accountable for it. The importance of maintenance should also be impressed upon consumers, since considerable leakage and waste take place in households also.

5.6 Improved low cost technologies have to be developed and adopted to save cost of construction and maintenance.

5.7 Tariff rates in the urban areas have to be so revised as to cover not only the O&M costs but also part of the capital cost, debt service plus some reserve fund.

5.8 Water for meeting the minimum requirements of the urban poor may be supplied at least at a nominal charge, so that they also realise the importance of treated water supply. The affluent sections of society should be charged at higher rates based on metered quantity.

5.9 Public Awareness needs to be created for reducing water consumption. Women's participation is to be encouraged to the maximum as they are major users.

5.10 Wherever feasible, artificial re-charge and rain water harvesting have to be encouraged. Instead of looking only for new and distant sources of water supply or tapping fast depleting ground water, local bodies should lay emphasis on water harvesting also.

5.11 As efforts by government alone will not be able to solve the problems of 100 per- cent coverage, public/private and community initiative in developing household or colony-wise systems, like withdrawal from dug wells should be encouraged.

5.12 In rural areas, where piped water scheme is operational or is proposed to be developed, the Maharashtra model may be adopted, in which local governments and users' committees participate in the development and maintenance of water supply systems.

Industrial Uses :

5.13 Tariff rates have to be prescribed such that the industry feels compelled to look into technological interventions leading to reduced use per unit production. For effecting maximum conservation, production processes have to be modified, to have lesser generation of effluent water.

5.14 Waste utilisation technologies/clean production technologies with emphasis on waste minimisation, recycling and reuse have to be encouraged for adoption.

5.15 Instead of allowing location of hazardous industries and insisting on Zero effluent condition in semi-arid and arid areas, industrial zoning be done in a manner that in such areas water intensive industries are not permitted especially those releasing toxic effluents. Hazardous waste treatment and disposal need to be so planned and sited as to protect people and environment from adverse impacts.

5.16 Selection and zoning of industries associated with potential risks especially those releasing toxic waste need a thorough analysis and planning before they are set up in any water basin. The concerned State Government and other local bodies should have a co-ordinated approach in selecting and locating industries of a specific nature with respect to their water requirement and facilities for wastewater disposal. A policy for zoning the water basins according to the types of industries, quantity of water consumed/discharged need to be laid down.

5.17 Minimum National Standards (MINAS) evolved by the Central Pollution Control Board based on minimum treatment concept have to be strictly followed while clearing proposals for locating industries in polluted stretches of water bodies. Apart from obtaining clearance from SPCB/ CPCB, clearance from the concerned Ministry dealing with Water Resources be made mandatory for discharging effluents in the drainage system.

6. Local Water Resource Development and Management

6.1 In a basin, there is a place for the whole range of structures - large to small. The latter has a particularly important role in rain-fed regions of the country.

6.2 Renovation and modernisation of tanks and other local water resources are to be considered as priority task. The programme needs to be planned and implemented on a watershed basis, taking into account the comparative techno-economic feasibility of renovating existing tanks vis-à-vis construction of supplementary tanks, upstream and downstream.

6.3 There is need for optimum use of local sources of water even in canal-irrigated areas, in the interests of efficiency of water use, extension of irrigated land, prevention of water-logging and increased productivity.

6.4 Due importance should be given to local water planning, with the ultimate aim of making each rural area manage its own water needs as far as possible through water harvests, conservation measures and watershed development.

6.5 At every stage, from the very beginning, people concerned must be involved in working out the project plan. It shall be the duty of the District Planning Commitee (DPC) to ensure this, before approving any project. The departmental and people's responsibilities may be indicated in each project by the DPC. The DPCs should also determine in each case the relative roles of panchayats, concerned beneficiaries and voluntary organisations. While local data should be collected by the DPCs through trained volunteers and other means, governments should arrange to provide remote-sensing data to an increasing scale, in co-operation with NRSA. A data base should be established and constantly updated at the district level.

6.6 State Governments should establish technical bodies at the local level, on the lines of Nirmiti Kendras for constant interactive relationships between the programmes and the people on technical matters and for use of low-cost and local materials.

6.7 The integrated projects should have a carefully worked out and mutually accepted sharing of costs and benefits and arrangements for faithful implementation. The special requirements of landless, women and other disadvantaged groups should find a place in the arrangements so made. The role of Central and state Governments should be to lay down the objectives of the programme and the broad essentials, to integrate the present schemes into one umbrella programme, to restructure the funding arrangements and departmental personnel suitably, in addition to the important functions of data collection, training, research studies, evaluation and dissemination of findings of experience in different states and regions.

6.8 The Government of India should bring together all the area programmes of different Ministries as well as the rural employment and development programmes into one 'integrated rural area programme' (IRAP). For each eco-system-arid, semi-arid, dry-sub-humid, hill, wastelands, wetlands, heavy rainfall regions, irrigated plains – different, location –specific programmes will be drawn up locally under this overall programme. All the existing programmes have to be merged into this and should not continue on parallel lines. New schemes should not also be added on an *ad-hoc* basis. An integrated watershed development programme (IWDMP) should be an important component of the IRAP in all areas. At the central level, the responsibilities for IWDMP should be that of the Ministry of Water Resources.

6.9 The available resources for all the existing programmes (to be merged) should be pooled together as the fund for the IRAP. It should be distributed districtwise on the basis of criteria to be laid down by the NDC. The DPC shall sanction projects within the outlays so allotted. At least one-third of the available funds for IRAP should be earmarked in each district for IWDMP.

6.10 In the districts, personnel dealing with Area Programmes as well as those dealing with soil conservation, minor irrigation, social forestry and related subjects, as may be appropriate, should be brought into one inter-disciplinary agency, replacing the existing DRDA etc.

7. Inter-basin Transfers

7.1 The approach to inter-basin transfer is that optimal utilisation of land and water should first be aimed at in basins with possible surpluses. After meeting such essential requirements, if there is surplus water available in the basin, its transfer to other basins may be considered.

7.2 Inter-basin transfer of water is an outstandingly large complex programme of water management. Studies have to be done with the help of computer simulation models and systems analysis. The Agency working on inter-basin transfer should undertake such studies sub-basin-wise, taking both surface and ground water resources into account. Computer simulation models are urgently required even for intelligent and coordinated operation of a number of storages already built or under construction in these basins. Social and environmental impact studies as well as studies on economic viability have also to be undertaken on an elaborate scale.

7.3 Inter-basin transfers are being studied in two components. Preliminary studies show that the Peninsular Component is technologically and environmentally feasible but economic feasibility and need for inter-basin transfer has to be evaluated after detailed studies of water balances. Studies of important east flowing peninsular river basins, namely Mahanadi, Godavari, Krishna, Pennar, Cauvery and Vaigai indicate that there is no imperative need for large scale transfer of water. Reasonable projected water demands of these basins can be met from within the resources of the basins except for marginal shortages in Krishna, Cauvery and Vaigai, with the proposed enhanced irrigation intensities. However, limited transfer from Godavari towards Krishna, Cauvery and Vaigai would be desirable.

7.4 With respect to Himalayan Component, which envisages transfer of water from water rich Brahmaputra and lower Ganga basins towards the western region as also to the Peninsular Component, detailed evaluation remains to be made as the reports and studies are classified. On the basis of published information, the Himalayan Component would require more detailed study, using system analysis techniques. Actual implementation is unlikely to be undertaken in the immediate coming decades.

8. Legal and Institutional Framework

Legal Issues :

8.1 In the present political climate, it may not be feasible to amend the Constitution to include 'water' in the union or concurrent list. The Union may pass laws to more effectively deal with inter-state rivers, for which it has powers under the Constitution. There is also need for the Union to put in place centre-state consultative mechanisms of effective kind through which the centre and the states could agree on a number of issues relating to water.

8.2 There is an urgent need for enactment of a law on inter-state rivers (in the place of the River Boards Act) to be called the Inter-State Rivers & River Valley (Integrated and Participatory Management) Act, which inter-alia may provide for the constitution of River Basin Organisations and for their powers and functions. The act may also provide for data collection and studies to be made by the Union for possible inter-state inter-basin transfers, so that the work of NWDA has statutory backing and the organisation would be able to obtain information and cooperation for its studies.

8.3 There is need for institutional arrangements with the requisite legal backing for making the states to come together for holding serious discussions on sharing of waters including diversion to non-basin states, ultimately paving way for reaching an agreement on the basis of mutual needs. One such arrangement would be River Basin Organisations of the respective basins. Efforts for seeking mutual agreement on inter-state water disputes should first be made at the river basin level, through the mechanism of the River Basin Organisation (RBO). The method of conciliation can be tried by the RBOs. However, if the dispute cannot be resolved within a reasonable time by these means, it may be referred for adjudication by a tribunal or to NWRC.

8.4 In order to ensure that awards of inter-state water tribunals are given within a reasonable period of time as also the effectiveness of such awards, immediate steps should be taken to amend the ISWD Act on the lines suggested by the Inter-State Council, with the following additions :

- Provision may be made for efforts for settlement at the river basin level, as and when RBOs are formed.

- When any matter is referred back to the tribunal for clarification under Section 5(3) of the ISWD Act, the tribunal should give its final verdict within a period of six months and the Central Government shall notify and publish the award/decision of the tribunal within three months.

- The tribunals should hear the views not merely of the contestant states, but all other stakeholders, who may implead themselves in response to a public notice and who, in the judgement of the tribunal, have a stake in the dispute.

8.5 So far as the major and medium rivers and streams are concerned, the state may continue to have the right of regulation, collection, retention and distribution of water. However, small rivers and minor streams could be managed by the village communities and the laws should enable this.

8.6 It is necessary to introduce participatory process in the ground water management in which the role of the state could be that of a facilitator or empowerer and the prescribing regulator, and the role of the community organisation as an implementing regulatory agency of the scarce resource. This is to be provided for in the law on ground water that would have to be enacted.

8.7 The following legal and institutional mechanisms are suggested for immediate regulation of ground water in 'dark' and 'over-exploited' areas :

- The overall guidelines of regulation may be prescribed by the Ground Water Authority concerned, based on local studies and surveys ;

- Panchayat should get approval of the Gram Sabha (village community), as a whole on ground water management ; where villages are large, the Sabha could be formed for smaller areas.

- The use of ground water for irrigation would similarly require approval of the Gram Sabha. This would ensure that the village community determines whether the ground water should be used and if so, in what quantity, based on the technical information and the advice received from the state ground water officers.

- The sale of ground water needs to be prohibited in 'dark' and 'over-exploited' areas for the simple reason that it converts a scarce natural good into 'commodity' and dealing in commodities must meet the requirements of public interest, which it does not do.

- The village community may be inspired and enabled to undertake ground water recharging operations and conserve the utilisation of water in the village area.

- The central and state ground water officials may be required to extend full cooperation, rendering technical service and advice to the village communities.

8.8 The Draft Rivers and River Valleys Statistics Bill circulated earlier has several weaknesses. There does not seem to be need for a separate law for this purpose. Suitable provisions in the proposed Act on Inter-State Rivers as well as the Environment Protection Rules and notifications (as regards ground water) would enable collection of required data.

8.9 The general laws on environment protection and pollution control are in themselves not adequate to arrest and reverse the trend of deteriorating water quality of inter-state rivers. For this purpose, more specific laws, mechanisms and inter-state agreements have to be worked out on the analogy of the European conventions and agreements. It is suggested that the restructured CWC should take the initiative to catalyse discussions in this regard, so that laws and conventions and necessary institutional mechanisms could be worked out

8.10 The old irrigation acts are based on a concept of a social contract which is not appropriate in the present times. Instead of legitimising a top-down hierarchical relationship, the new social contract has to legitimise relationship of co-equals or partnership between the irrigation bureaucracy and the water users. The state irrigation Acts should be farmer-friendly.

8.11 The following changes are essential in the existing statutes and the rules framed under them :

- Irrigation Acts should be enabling laws, so that PIM initiatives become possible.

- Within the areas of operation, WUA or FO has to be given powers that today are vested in state irrigation departments so that the institutional base of village level associations can be strengthened. In particular, WUAs/FOs require an independent resource base and an enabling organisational structure, which represents various interest groups and makes water user organisations accountable to farmers.

- The farmer's right to water(that is, the agreed quantum) has to be recognised in law and under rules framed under them. Without this, the overriding principle of accountability and transparency cannot be established. Both are needed to make PIM strong and functional.

8.12 To cover various issues like access to water to be recognised as a basic right, right of the community over common resources, environment, water rights and many other related aspects, a comprehensive National Water Code, that is, not one single law but an integrated set of water laws, may be needed. Such codes have been framed in a few countries and have been found to be extremely useful. It is suggested that a National Water Code may be got prepared with the assistance of the Law Commission.

Institutional Aspects :

8.13 The need to form users' bodies (Water Users' Associations, Farmers' Organisations) at the ground level for watershed development and management, for operation and maintenance of field canals and for ground water use and regulation, as the case may be, is reiterated.

8.14 For the suggested functioning of WUAs and FOs, several characteristics and conditions seem to be relevant, as detailed in the Report. These have to be ensured.

8.15 There is need to evolve a legally and institutionally enforceable system, which will ensure sustainability and provide the parameters within which water markets could operate.

8.16 Above the field level and below the state level, water districts may be formed, as has been successfully done in many countries. The water district management should comprise of representatives of all types of water users and the local governments. Agriculture and drinking water supply interests would have special representation and they should also be empowered to take decisions. The composition of the water district bodies and the setting of hydrological boundaries for each water district and the frame work of regulation have to be devised by each state and incorporated in the irrigation law. A uniform composition for all states is not advisable.

8.17 For all inter-state rivers, there is need to set up the RBO, a body in which the concerned State Governments, local governments and water users would have representation and which would provide a forum for mutual discussions and agreement. RBO may consist of a General Council and a Standing Committee. It shall be the function of RBO to collect data and disseminate them in local languages, formulate integrative plans and consider the proposals from constituent states on various issues including project proposals in the basin and monitor implementation of large projects.

8.18 The CWC should be restructured into a statutory high powered inter disciplinary commission, with maximum autonomy, in order to deal with policy and reforms, centre-state and inter-state issues, planning and project finalisation, international aspects other than those that have to be retained with the Ministry ; legal, economic and financial issues, water productivity, conservation and management, environmental aspects and rehabilitation, people's participation and communication, coordination and facilitation of inter-disciplinary research, HRD and training and a National Information/Data System. CWC may consist of six full time members, that is, three more members than at present, one for HRD and administration, one for economic and social aspects and other for environmental matters. The Commission may have three ex-officio members, namely, Chairman CGWB, Director-General, NWDA and Director-General, IMD. The Central Ground Water Board will be a separate organisation linked to the restructured CWC with its Chairman as an ex-officio member of CWC.

8.19 In our view, the Chairman, CWC should actually function as a Secretary to government in the Ministry in respect of certain responsibilities. We suggest that the entire question of restructuring of the CWC may be got studied in detail, by appointing competent consultants. The study may cover CGWB and the interrelationship and linkages between ground water and surface water organisations at the central and state levels.

8.20 For efficient irrigation management, certain organisational and procedural changes necessary in the state irrigation departments were suggested to all the states in 1992. The changes are designed to ensure that the organisation assumed a clear functional identity, with horizontal broadening and the integration of multidisciplinary status, acting at the field level as support services to farmers' organisations. The restructured CWC, by taking this up as a priority item, should persuade the states to adopt the changes. On the lines of restructured CWC, State Commissions may be modelled in due course.

8.21 NWRC is a high level centre-state political body which meets at long intervals. It may take steps to constitute committees, groups and even appoint eminent persons as mediators/facilitators so as to have sustained, serious discussions and negotiations to arrive at solutions. The Chairmen of RBOs as and when constituted may also be the members of the Council.

9. Economic and Financial Management

Financial Aspects :

9.1 Since a number of major projects are continuing over the plan period, the costs are increasing & the benefits are delayed, it is essential that a detailed review and evaluation of the ongoing projects is done during the Ninth Plan, so that appropriate lessons may be drawn and remedial measures taken in each case, at least in the Tenth Plan.

9.2 Detailed micro-level studies are needed to evaluate the longevity and viability of minor irrigation schemes. Since substantial institutional funding is involved, NABARD should take the initiative to finance such independent studies.

9.3 The entire treatable area should be covered by integrated local watershed programme by the end of the Thirteenth Plan with both government's and people's initiatives.

9.4 Private sector participation would be practicable in projects mainly intended for supply for industrial use and urban water supply and for these components in other major projects. The experience of operationalisation of initiatives taken by States of A.P., Karnataka, M.P, Maharashtra and Orissa have to be evaluated and appropriate lessons drawn from it.

9.5 For field level works in the case of major projects, minor irrigation works, repairs of tanks and other works in rural areas, as much funds as possible should be generated through community involvement.

9.6 For main works of the major projects, government funds would continue to be the principal source and they have to be better applied and managed.

9.7 All the means for augmenting government's resource have to be encouraged to the maximum extent possible. To the extent they are successful, many neglected activities can be better looked after and there will be release of pressure on government funds.

9.8 Urgent steps are needed to prevent more damage and for proper up-keep and maintenance of existing irrigation systems on the lines suggested in the Report.

9.9 The following measures are needed for immediate adoption to instill a measure of financial discipline in the system :

<u>Major Projects</u>

- As was the case in the early years of the plan period, assistance to large projects may be projectwise from 2000 AD, instead of being part of the overall plan assistance. The assistance for large projects may be deducted from the central assistance to a state and kept as a separate pool/fund. Within a large project, funding could be earmarked for phases and sub systems also.

- The procedures for release of AIBP funds require change and it is necessary to assess minimum number of years to complete the project/phase and provide funds for that period in a non-lapsable manner.

- Revised estimates may be got prepared in the next two years (1999-2001) for all the ongoing projects. A Monitoring Committee may be constituted for this purpose. Thereafter, the estimates so revised may be got revised every year of the plan period.

- In the case of new projects, the project cost should cover escalation over the proposed construction period and the project should indicate both the basic cost and the estimated completion cost. The cash flow assumed in the Project Report should be got certified by the state finance and planning departments, to indicate the state government's commitment.

- In the absence of clear understanding as to when a project should be considered as having commenced and completed, it is necessary to lay down the criteria regarding these for all to adopt :

    A project should be considered as having commenced, only after the issue of formal administrative and technical approval by the government, after clearance by the Technical Advisory Committee. All expenditure incurred prior to this should be shown against investigation and preparation.

    Major projects should be broken into identifiable and meaningful phases/sub-systems/components. 'Completion' should be considered for each such phase / component. The irrigation component should be considered to have been completed, if 90 percent of the physical progress is achieved and the status continues for one year and if at least 80 percent of the estimated potential is created. The balance will be dealt with as a separate scheme.

- A Completion Report should be prepared for each project phase. To ensure this, an amount of Rupees one to two crores may be retained in the final bill for reimbursement under project financing. The amount may be released only if the Completion Report is itself completed.

- Since establishment costs are soaring and in the extended period of projects rise to unconscionable levels, a ceiling on establishment costs (including work-charged) should be enforced. The ceiling should be 20 percent of the cost and every effort should be made to keep it around 12 to 15 percent. Expenditure above 20 percent should not be reimbursed.

- The scope of a project should not be allowed to change, except after prior mid-project appraisal and specific approval. If there is change of storage/capacity of main canal/potential over 10 percent of what was envisaged at the time of approval of the project, a project should be considered to have changed in 'scope'.

Medium Projects

- The CWC should concentrate on large projects and monitor them more closely. The approval and implementation of medium projects may be left to the states. It may be laid down that in all such cases, the state proposing the project shall notify it in the Gazette and to the concerned states with full details of the parameters laid down by the CWC. If there are objections, within the prescribed period, they should be sorted out mutually or through the Basin Organisations.

- The principles regarding commencement, completion and establishment costs suggested for major projects shall apply to medium projects also and it is for the state authorities and audit to ensure them.

9.10 Measures should be taken to increase revenue from water rates substantially. For such increases to be accepted, utility and efficiency of the system should be increased through savings of working expenses through modernisation, better water management, organizational reforms, improved infrastructure and reorientation in O&M costs by curtailing overstaffing, providing better communications and establishing participatory management.

9.11 With the background of the past proposals, especially the detailed ones made by Vaidyanathan Committee, the following general principles are recommended regarding increase in water rates :

- The water rates should cover the entire annual O&M cost plus one per cent of the gross value of the produce/ha in respect of cereal crops and a higher percentage in case of cash crops. These rates should be levied as single part variable tariff for the present. However, the logic of charging a basic fixed rate alongwith a variable part is quite logical and should be followed up with the state Govts.

- Some states have supplementary levies like betterment charges, Mandi-charges etc. The states may consider continuing these additional charges.

- There should be rationalisation of basic principles of fixing the water tariffs in all the states. The revised water pricing structure should be such that the rates are substantially lower for those who accept group volumetric supply than for individual farmers. Also, the WUAs should be allowed to collect a little over and above the prescribed water rates to encourage them improving the system under their charge.

- Though area, crop and season based tariffs are in force in various states, at present they require *inter-se* rationalisation to reflect varying degrees of water consumption by various crops and their economic values. Looking to the extremely low existing rates and the policy of subsidising water which has been continuing since several decades, it is not practicable to enhance at one-go the water rates. Subsidies in the rates in the form of lower percentage applicable to gross value of the products will have, therefore, to be continued for sometime and gradually phased out.

- Realistic O&M costs/ha should be worked out by each state on pilot representative systems by allotting adequate funds. These figures should be used for fixing of rates. However, in working out the cost, the ceiling rates on establishment charges should be followed.

- There should be two distinct components of irrigation water charges; one for O&M and other related to the value of the product. The O&M component should be fully utilised for the operation and maintenance of the respective portions of the system. The second part should be used to modernise the system with supplementation from budget allocations. Each state will have to decide the natural proportion of the two components based on its figures of O&M and the productivity of the crops. The financial procedures should be modified to make this possible, so that the farmers are encouraged to pay the enhanced rates. The rate structure should differentiate between the seasons and also the crops in such a way that production or benefits are optimised per unit of water or at least indicate the intention. Thus the rates should be so rationalised that the water intensive crops are charged proportionately more as compared to less water consuming crops.

On the basis of previous hydrological records, the existing surface irrigation projects should be classified into those with performance reliability of (a) 75 percent or above and (b) less than 75 percent. Considering a minimum reliability of 50 percent, the water rates for the latter should be two-thirds of the full rates fixed for the former. The objective should be to achieve volmetric measurement ultimately, though gradually, and this should be kept in mind at every stage. The change should encourage user group formation and give adequate incentive to group consumers, who can be supplied water on volumetric basis, over individual consumers who have to be charged on crop area basis.

- The pricing for water of lift irrigation schemes should be worked out on the basis of the capital and O&M costs of these schemes. As this water will be easily measurable, the tariff should be fixed on volumetric basis. The schemes can be categorised according to lift ranges and rates be fixed for different categories.

9.12 In the case of supplies for industrial purposes, the principle of 'user pays, polluter pays' has to be applied and water charges fixed accordingly, adopting a premium for security, in water scarce regions. In the case of domestic supply, a certain fixed quantity per connection may be fixed, in addition to the public taps, and charges increased progressively for larger use. The principle of seasonal water rates could also be tried.

9.13 The details of rates have to be worked out and operationalised in each state, perhaps separately for regions in large states or even for projects. It is felt that a uniform formula for the entire country would have no practical value. It is recommended that a Water Pricing Authority may be constituted in each state by statute, on the analogy of the energy pricing authorities and the general principles as suggested in this Report, with suitable local modifications, incorporated as guidelines for the Pricing Authority.

10. Project Planning and Prioritisation

10.1 There is need to make changes in approaches to project planning, particularly in respect of allocation of water among various uses, dependability and carry over related issues, conjunctive use, water lifts, project and viability criteria. INCID & CWC have issued guidelines in regard to conjunctive use. The extent of their implementation and effectiveness has to be studied for improving the techniques.

10.2 Planning Commission may lay down improved procedures of benefit-cost analysis after considering all relevant aspects, such as technical, financial, economic, social and environmental.

10.3 It is necessary that participation of members from the Ministries in the TAC is effective so that delay in giving mandatory clearances is avoided.

10.4 Processes for detailed appraisal, establishment of techno-economic viability, regular monitoring of physical and financial progress as well as of resettlement and rehabilitation and funding in accordance with project programming schedule, which are followed in the case of externally aided projects, should be adopted for all other projects.

10.5 Efforts should be made to constitute Joint Corporations (centre and state/s) for selected projects with a M.O.U and arrive at an Agreement for joint management.

10.6 For speedy completion of projects, efforts need to be made for substantial changes in the contractual procedures as suggested in the Report.

10.7 Planning Commission and Ministry of Water Resources should insist on each state to prioritize major projects on the basis of guidelines and revised system of points recommended in the Report by using an Excel based Programme developed by the Working Group and accepted by the Commission. Release of plan funds for a project should be contingent on such prioritisation.

10.8 Guidelines have to be applied at the level of the state governments which is the most relevant level for making decision about the implementation of important projects. Prioritisation cannot be a one time exercise since there is a continuing addition to the stock of possible projects. The exercise should be done before each Five Year Plan.

10.9 Prioritised major projects could be phased further into identifiable sub-systems for implementation. Phasing should be supported by specific financial outlays for better monitoring and financial discipline.

11. International Dimensions

11.1 Though India is not a signatory to the UN Convention on the Non-Navigational Uses of International Watercourses, we could draw upon the principles enunciated therein usefully for the purpose of evolving an interpretative matrix not spelt out in our bilateral treaties.

11.2 The optimised and integrated development of South Asian and trans-Himalayan river waters calls for cooperation amongst the countries and India should work for such cooperation.

11.3 Augmentation of the lean season flows of the Ganga can be secured by local rain water harvesting, conservation and demand management over a period of time. But additionality can only come through storing the monsoon flows, especially in the Nepal Himalaya or through transfer from the Brahmaputra system. The Sapta Kosi High Dam offers the best prospect of augmentation and this possibility will need to be kept in mind when the design and operational parameters of the project are decided. A lesser quantum of augmentation may be possible from other major storages and through groundwater recharge, and through exploitation of deep aquifers if their techno- economic parameters are established to be favourable.

11.4 Calcutta Port studies should be undertaken with respect to its long term flushing requirements in relation to alternatives such as new ports and inter-modal transport with a strong inland water navigation component.

11.5 Augmentation of Teesta and Ganga flows could also come through possible storages on the Dharla, Dudhkumar, Sankosh and Manas in Bhutan.

11.6 The Brahmaputra river, which is virtually untapped, is an obvious potential source for transferring supplies for supplementation elsewhere. Various potential alignments for water transfers from the Brahmaputra have been proposed, some limited to Bangladesh, but others extending into India either through Bangladesh or through the Siliguri neck. Obviously, careful techno-economic planning and environmental care will be necessary and optimisation and integrated development of the system will require bilateral and regional cooperation.

11.7 The problem of several other common rivers in the Cachar-Tripura sector can be subsumed in the Tipaimukh benefit area if the dam on the Barak and the associated irrigation barrage at Fulertal is taken up. The studies agreed upon in the JRC should be vigorously pursued.

11.8 India would benefit by storages in Nepal to moderate floods and expand irrigation in the Uttar Pradesh and Bihar plains. The Mahakali Treaty is a good example of bilateral cooperation in joint water resource development and such cooperation should be continued for other projects.

11.9 The reported project proposals in the Upper Brahmaputra basin in Tibet (China) for power generation and diversion for irrigation, though futuristic, need to be noted.

11.10 There is scope for Indo-Myanmarese cooperation in jointly developing the hydro potential of the Chindwin to mutual benefit.

11.11 India should fully utilise the permissible pondage/storage in the Western Rivers, viz the Indus, Chenab and Jhelum for hydro-electric development and for achieving the prescribed irrigated cropped area at the earliest.

11.12 The satisfactory disposal of saline waters from the IGNP command requires detailed study. One of the solutions would lie in negotiating with Pakistan, for an outlet to its Left Bank Outfall Drain or other systems in Sind on the basis of a suitable *quid pro quo*.

11.13 India would find it useful to negotiate additional inland water transit routes through Bangladesh including some inter-modal routes.

11.14 Unless storages are built upstream in Nepal to augment the lean season flow, no navigation in the Gandak will be feasible. Therefore, of all the available options, the Kosi navigation link appears the most viable.

11.15 Flood moderation and forecasting is a matter of common concern and there is need for improving hydrological and silt data and transmission in real time . Likewise, flood embankments need to be tied together across national boundaries. There has to be agreement on construction of anti-erosion and flood protection works along common or successive rivers so that one country's solution does not cause problems to the other.

11.16 The GBM and Indus basins are endowed with a huge hydro potential which has only been harnessed to a very limited extent. This power can be traded across frontiers through power exchanges as hitherto or, more meaningfully, through an interconnected grid. It would probably be cheaper to transmit Northeast power to the Indian heartland via Bangladesh, making sales to that country *en route*. Bangladesh itself seems poised to make large gas discoveries in which case an integrated energy grid could be contemplated and Bangladesh gas traded for Indian hydro- power.

11.17 Asian Development Bank has funded studies regarding two sets of power links between Bangladesh and India and the linking of Indian regional grids and formation of a national grid. These developments require to be well planned instead of being taken up in a piecemeal and *ad hoc* fashion and some machinery for forward regional planning and joint consultation would be necessary.

11.18 Cross border water monitoring and establishment of common regional standards as in many other matters, would be very useful. The threat of global warming and climate change has engendered new concerns. The point to study and concert action in South Asia is the extent to which emissions trading can be used to generate funds for clean Himalayan hydro power and in negotiating the fine print so that the terms are right.

11.19 Foreign and Indian investors have shown interest in engaging in hydro development in this country and in Nepal. This would raise several issues and calls for the evolution of a clear policy framework. The effects of regulation of major dams to be built through private investment in Nepal and Bhutan and their safety would need to be examined at an early stage of negotiations in order to prevent adverse effects, if any, in India. Expertise has to be developed with regard to financial and techno-economical aspects as well as in negotiating skills.

11.20 Transparency, public awareness and stakeholder participation are the pathways to future water resource development. This will be more so in respect of trans-boundary projects as also to combat the rise of hydro-politics. Political will is sure to be strengthened by genuinely consensual approaches.

11.21 There is utility in strengthening certain existing mechanisms such as the JRC by giving it a permanent secretariat and some funds. There would certainly appear to be a strong case for designating certain bodies like, the National Water Development Agency (NWDA) in India, the Water Resources Planning Organisation (WARPO) in Bangladesh and the Standing Committee of the National Water Council or the Energy Development Authority in Nepal to interact and build up a data bank and clearing house of information. National basin plans for long term water resource planning and development could be exchanged through a regional forum in order to facilitate regional optimisation reflecting the highest common denominator of the national plans .

11.22 Capacity building for regional water resource development is also necessary. The emphasis should be on maximising local manpower, material and equipment, then going to the regional level and only thereafter going international in order to save heavy foreign exchange outgoes and to build national and regional self-reliance.

11.23 In the matter of capacity building, the role of universities, research institutions and NGOs has to be adequately recognised and promoted. It is essential that the scientific as well as the techno-socio-economic aspects of various issues are not allowed to be obscured by parochial and emotional considerations. Towards this end, Track-II efforts should be mounted and sustained by nurturing and strengthening suitable institutions which can also play a role in the creation of public awareness about issues relating to international water resources.

11.24 The time frame within which projects on the international rivers will materialise is uncertain and will in any event take up to two to three decades. Our planning should, therefore, proceed on the basis of varied scenarios. It would be also useful to study appropriate management structures for joint venture projects in Nepal and Bhutan.

11.25 The Government of India should consider setting up, say, a Rs. 1,000 crore revolving fund to extend supplier's credit for Indian equipment and material to support water resource development in Nepal/Bhutan and elsewhere.

11.26 Studies should be initiated for a South Asian power grid and a wider energy grid for hydropower, coal, nuclear power, oil and gas. There is need to restore the GBM river system as a unified inland-cum-coastal waterway and encourage public and private carriers to develop and operate barge and coastal fleets with inter-modal/transhipment linkages. This will require a legal framework and agreed documents, customs procedures, bonded warehousing etc.

12. Water Quality and Environmental Aspects

12.1 Water projects have both beneficial and detrimental effects. The project authority should weigh all alternatives before going in for a project so as to cause the least social and environmental disturbance.

12.2 A catchment treatment programme for arresting the degradation of the catchment areas and restoring ecological balance needs to be planned as part of a project.

12.3 Integrated watershed projects help in water and soil conservation and thus enable restoration of degraded areas.

12.4 Much of the criticism against major developmental projects including water projects emanate from poor R&R, and, therefore, R&R of PAPs should receive total attention. The following should form the core R&R plan:

- The R&R plan should be prepared alongwith the project but implemented well ahead of the project completion. There should be perfect timing so that all PAPs are settled well before the reservoir is filled in. R&R should be taken as the obligation we have to the people, who have to suffer on account of the project and should be dealt with as such with human compassion and sensitivity.

- The R&R plan should receive sufficient funds and be implemented by a functional authority. It should be vested with powers to deal with the affairs of the state, to the extent, it is concerned.

- Special care should be taken that the minimum extent of land required alone is proposed for acquisition

- The project advisory steering committee must be broad based to include representatives of the PAPs, NGOs and representatives drawn from the concerned departments/agencies.

- Apart from periodic assessment of the R&R plan, there should be an assessment made 5-7 years after its full implementation, to see how the PAPs have done for themselves. If further support/interventions are required, they must be provided.

- A complete survey of the affected zone and people, their occupations etc. should be taken in this respect, wherever tribals are involved.

- Compensation packages should be well laid down to take care of all categories of displaced persons. They would include land for land, homesteads for all including the landless, cash compensation, training for vocations, employment and so on. As far as possible, cash compensation is not to be considered for tribals as they are tied to land in their way of life and are not careful in handling money.

- Tribals must be given special attention. They should as far as possible be settled in habitats, closer to the ones left behind by them and without breaking their group identity.

- The resettled sites should be well developed with all infrastructure so as to provide the resettled a better way of life.

- Support to the landless, unemployed should be extended, through appropriate means, to enable them to rehabilitate themselves.

- There should be active involvement of the displaced in the R&R activities and flexibility to the extent required should be built into the plan.

- NGOs should be involved to the maximum extent possible, in the formulation, implementation and follow up of the R&R plan. They are based locally and will be able to build up the confidence of the resettled PAPs and reduce local tension between the locals and the resettled PAPs.

12.5 Infrastructure, training material etc. should be improved and updated to increase the efficiency of the institutions and persons involved in the sector so as to effectively deal with environmental issues.

12.6 There is need to establish and operate cost-effective water quality monitoring systems. Adverse effects of agricultural activities on water-quality are to be prevented. It is essential to establish biological, physical, chemical water quality criteria for users. Action is to be taken to minimise soil runoff and sedimentation. Proper disposal of sewage is to be ensured. Communities are to be educated about the pollution-related impacts of fertilisers and chemicals on water quality.

12.7 Application of 'polluter pays' principle is needed to prevent water pollution. Treatment facilities for domestic sewage and industrial effluents are to be improved and standards for discharge of effluents and for the receiving water are to be established. Mandatory EIA of all major water resource development projects, use of risk assessment and risk management in reaching decisions, identification and application of best environmental practices are needed to avoid pollution.

12.8 Water quality monitoring is done by Central Pollution Control Board, State Pollution Control Boards, CWC and CGWB. Although they are engaged in the same task, they are working in isolation and without interaction as well as coordination on a continuity basis. There is need to set up a mechanism for effectively coordinating the work of water quality monitoring by these organisations. This would help to decide upon corrective/remedial measures.

12.9 To restore and maintain water quality and ensure environmental susceptibility, action is needed on a wide front under water resources protection and conservation, water use efficiency, water quality management, drainage and control of water logging and salinity, prevention and control of water pollution, development and application of clean technology, ground water protection, monitoring and surveillance of water resources and water receiving wastes. The actions needed are not beyond the present status of our knowledge of science and engineering and of social sciences.

12.10 A number of programmes have been initiated to restore water quality and sustain our rivers, lakes and wetlands. Experience gained in the implementation of Ganga Action Plan (GAP) - I should be utilised in the further phase of GAP as well as in the National River Conservation Plan. The National Lake Conservation Programme and the Wetland Conservation Programme need to be expanded with additional outlays.

13. Research and Development Needs

13.1 It is necessary to build systematically a data and information system, scientific in approach and comprehensive in coverage, simultaneously with a system of data exchange and information dissemination in order to address our concerns in the water sector effectively through research and development.

13.2 The secrecy maintained about water resources data for some of the basins is not only highly detrimental but is also counter productive. Hydrological data of all the basins need to be made available to the public on demand. Also, continuously updated data should be published periodically and made available to water planners, economists, administrators, scholars and other interested members of the public.

13.3 Considerable work has been done regarding surface water availability but as the studies themselves indicate, further refinement is warranted through the modelling of the hydrological cycle. One issue that may be mentioned is further analysis of contribution from snowmelt and glaciers, which is particularly important in the Himalayan rivers. Another important component to be studied is assessment of the return flows. The current figures are not really dependable. This will have to be closely related to demand analysis and management.

13.4 Desalination of saline and sea water is a relatively high cost alternative, normally employed as the last resort. However, in arid areas near the sea coast, it may be competitive with tanker supply and may prove viable. Continuous improvements in membrane technology are bringing down the costs and research needs to be stepped up in this area.

13.5 Estimation of water demand and its implications on water quantity and quality are extremely important. Related to it is the management of water demand, through technology, policy and specifications. For planning purposes, more refinement in the assessment of water demand is needed.

13.6 Research is needed to provide guidance to the farmers, to obtain maximum production per unit of water for different crops suited to their climatic and soil conditions. Crop planning itself has an important bearing on water demand and of course on farmer's income.

13.7 For domestic water supply, research needs to be directed towards supply of safe water at minimum cost. Evaluation of latest technologies for sedimentation, treatment and purification is needed. For sanitation, the evolving techniques using smaller quantity of water need to be evaluated and improved. For sewage treatment, research effort should be directed towards defining the design parameters for low cost low energy intensive techniques, like oxidation and duckweed ponds. Recycling of treated wastes for industrial use and irrigation has to be promoted subject to requirements of safety. This is also a field in which research will be rewarding.

13.8 Research is needed on the actual observed impact of existing high dams and other irrigation systems on environment with respect to river regime, ground water, flora and fauna, human health, quality of life etc.

13.9 Research is also needed to assess the impact of large scale interbasin transfers on donor and donee basins with respect to biology, sociology and economics.

13.10 The subject of climate change and its impact on water has been mentioned under issues to be taken into account while determining the development policy, but in view of the uncertainty of the subject, considerable research is required. This also raises the issue as to how uncertainty has to be handled in decision making. The subject needs considerable research.

13.11 More research effort needs to be directed towards legal and socio-economic aspects of irrigation and water resource development and management in general. The impact on income, employment and acquisition of household goods needs to be evaluated. The equity aspect is also important : do the disparities in income really increase in an irrigated area as has been stated by some social scientists? How are the thorny questions of rights on ground water to be resolved ? The impact on the work load and status of women of farming families and the changes in their quality of life also need to be investigated.

13.12 There are several fields where further research is needed for technological innovations such as in sedimentation studies, river morphology, forest hydrology, designs and model studies for specific structures, construction technologies, new materials etc.

13.13 If the results of the research work are not properly documented, they do not become available to other potential users, who may be facing similar problems. It is extremely important that all research results are properly documented and published. The completion reports of important projects would record problems faced and solved and will be highly educative.

13.14 Effective networking and co-ordination of research work done in different institutions is essential to maximise their benefit and avoid duplication of effort. Intercommunication between research workers active in the same field and in different disciplines enhances progress of the work and evolution of new policies and systems. The restructured CWC should give special attention to coordinated interdisciplinary research by drawing up priority research agenda from time to time and funding them. It is not necessary to try to start new institutions. The task can be done by strengthening existing institutions and by farming out and networking of research in institutions of other disciplines.

13.15 Most of the big states have got institutions for research such as Irrigation Research Institutes and WALMIS. These need to be made autonomous organisations in order to ensure the continuity of the persons and to give them flexibility in their functions

13.16 A regular personnel training policy needs to be evolved by each government and organisation. This policy needs to provide for adequate training, with emphasis on acquisition of knowledge in the early career, on acquisition of skills in the middle period and on managerial aspects in the later period.

13.17 For postings which allow professional development, such as those in design, planning, research institutes, training could be made mandatory. Some state govts. have prescribed, in their rules, such postings as essential requirements for promotion at specified levels. This seems to be an effective tool.

13.18 Persons need to be encouraged to obtain higher academic qualifications through study leave provisions. Persons with higher qualifications and exceptional performance should get faster promotions.

13.19 There is a need for much larger horizontal mobility, within a specilisation, amongst cadres and specialists. Similarly, exchange between academic institutes and line department personnel would be beneficial and service rules should enable this, ensuring equality of benefits.

13.20 Water professionals, at senior levels, could be given a choice. They can either branch into senior management and policy making responsibilities or could continue in their specialised fields striving for professional excellence and towards becoming a role model to the younger generation. Both the choices need to be equally attractive. Such a move could go a long way in changing the prevailing attitudes about co-ordination, management, administration and policy making to a healthy and superior level.

Report of the National Commission for Integrated Water Resource Development Plan: Some Reservations

Ramaswamy R. Iyer

It is with some reluctance that I write this note. I regard my membership of this prestigious Commission as an honour. The Commission has done a great deal of valuable work, and my association with this process has been an interesting and instructive experience. From time to time I have placed my own views and comments before the Commission both orally and in writing, and I can recognize places in the Report in which some of these have been incorporated or reflected or taken into account. I have also made a few modest contributions here and there to the formulation of the Report. Nevertheless, some significant differences and reservations remain and compel me to write this note.

2. The following are some of my principal reservations:

It was my personal view that radical changes were called for in our approach to water policy and planning, and I had hoped to persuade the Commission – the first National Commission on water as a natural resource - to make some strong recommendations in this regard. I failed in that effort. The Commission has remained within the ambit of what one might call the `mainstream' thinking on this matter, namely, proceeding from projections of demand to supply-side solutions in the form of large projects. It is this thinking that governs most of the chapters. There is indeed a chapter (Chapter 6) on local rainwater-harvesting and watershed development, but this represents an <u>accommodation</u> of a point of view that is gaining strength rather than a major shift in thinking on the part of the Commission. Besides, there is in fact a certain divergence between the approaches advocated in this chapter and what I have described as the mainstream line of thinking, and the attempt to accommodate both as complementary to each other seems to me unpersuasive.

This is an area of a significant difference of views between the Commission as a whole and myself. I do have serious reservations on large-dam projects and long-distance water-transfers, but I do not propose to enter into an elaborate discussion of these matters here. I have set forth my thinking in some detail in an article entitled `Water Resource Planning: Changing Perspectives' published in the Economic and Political Weekly issue dated 12 December 1998, which those who are interested could refer to. I shall reproduce here only some extracts from the concluding portion of that article, which outlines an approach for the future:

> "In the light of the foregoing discussion, what re-orientations are needed in relation to water policy? I would propose the following:
>
> (i) <u>Reversing</u> the usual approach of proceeding from projections of demand (as if demand were autonomous and sacrosanct) to supply-side solutions, we must proceed from limited availability to the response of demand-management and resource conservation. Such a reversal becomes even more imperative as water which is a scarce resource becomes still scarcer.
>
> ii) Water-resource <u>management</u> rather than <u>development</u> should become the watchword for the future. Economy in the use of this scarce and precious resource and the conservation of available supplies will have to be central to planning........

iii) Supply-side responses are not to be ruled out, but they need not mean only large projects. Significant augmentation is possible through local water-harvesting and water-management. The focus should shift from the basin or sub-basin to the small watershed (which is also a hydrological unit). Water planning should be essentially local. The effort should be to make each locality manage its own water needs through water-harvesting and conservation schemes. The thrust in future planning in respect of water must be towards bringing about a vast network of thousands of local initiatives..........

(iv) Traditional systems of water management, which have fallen into disuse, need to be revived and strengthened. This must be another `thrust area' in future planning. Similarly, the restoration of defunct water-bodies and the rehabilitation and preservation of wetlands should be taken up as urgent tasks.

(v) Large projects, if considered necessary at all, must be regarded as projects of the last resort, to be undertaken only after examining all other possibilities, and after a stringent scrutiny...
....

Such a reorientation cannot be easily brought about. However, the effort needs to be made. It is here, and not in grandiose projects, that the answer to future needs is to be found; and here, and not elsewhere, lies the route to true `sustainability'.......".

(ii) The Term of Reference `Inter-Basin Transfers' gave a certain direction to the Commission's thinking which prevented it from looking at the underlying problem in what in my view would have been a more useful and appropriate manner. Instead of assuming that the spatial variations in water availability in the country called for long-distance transfers of water and then examining the possibilities of such transfers, the more fruitful course would have been to identify all the chronically water-short areas in different States – for instance, Rajasthan, Gujarat, Karnataka, Andhra Pradesh, Tamil Nadu – and then examine how best the water needs of these areas could be met through local efforts (through local streams and water bodies, underground aquifers, rainwater harvesting, watershed development etc.) and to what extent water would necessarily have to be brought in through transfers from other areas. A series of area-specific approaches could have been outlined.

(iii) It seems to me that while water is the means through which hydro-electric power is generated, the issues that relate to hydro-electric power, such as the need for peaking power, the role of hydro-power in balancing the grid, the proper thermal-hydro mix etc., are issues of energy policy and not of water policy. Moreover, the importance of hydro-electric power is usually considered a clinching argument for large projects, but Dr. A. K. N. Reddy and others have put forward alternative approaches that the Commission should have taken note of.

(iv) The chapter on `International Dimensions' seems to me disproportionate on the one hand and inadequate on the other. This Commission is essentially concerned with national water-resource planning. However, in so far as some of our rivers flow into India from upstream countries, and some rivers in turn flow from India into downstream countries, we have expectations of flows from the former and obligations to maintain certain flows to the latter. This is the `international dimension' that the Commission needed to keep in mind. This could have been done in a few paragraphs (As regards the idea of a large hydro-electric power potential in the Himalayan rivers, that is a question of energy policy). It seems to me that the chapter on `International Dimensions' goes into matters beyond the purview of the Commission. On the other hand, if it was considered necessary to go into the details of the Treaties with Pakistan, Nepal and Bangladesh, a far more elaborate and rigorous treatment would have been appropriate. I also have reservations on the implicit equation of `Regional Cooperation' with a number of large projects in the Himalayan region, the thesis of `augmentation' of water through such projects, and the proposition that regional cooperation would provide better answers even to national problems; but I shall refrain from expatiating on them.

3. In addition to the above, the following are some comments on specific points or recommendations:

(i) In Chapter-8, in the discussion on the changes needed in the Inter-State Water Disputes Act 1956, there is a reference to the suggestion (mine) that an appeal from the Award of a Tribunal to the Supreme Court might be provided for. While I have no quarrel with the non-acceptance of my suggestion by the Commission as a whole, I should like to explain the thinking behind it. It was intended to be a solution to the problem of non-implementation of the awards of Tribunals. If the Supreme Court were to hear an appeal and give a decision, it would be difficult for a State Government to refuse to implement it; further, the possibility of an appeal would also remove any basis for a sense of grievance on the part of any of the parties to the dispute. As for delays, my suggestion was part of a set of proposals including reductions in the time allowed for the establishment of a tribunal, the giving of an award by the tribunal etc.; thereafter, if some time were allowed for an appeal to the Supreme Court, the total time taken by the process could still be less than the time now spent. I am not offering my suggestion in a dogmatic spirit; I am merely saying that it deserves consideration by the Governments, Central and State (I have dealt with this matter more fully in an article entitled `Inter-State River Water Disputes: Some Suggestions" in the <u>Mainstream</u> issue of 5 June 1999).

(ii) I entirely agree that the Central Water Commission should be radically restructured and made into an inter-disciplinary body. I have been saying this for a long time. I also agree that the CWC should be made autonomous and `empowered', but I am not entirely sure that the best way of doing this would be to make it double as a Ministry on the Railway Board model. I have not reached firm and final views on this matter; I feel that this needs further examination.

(iii) While I can see the force of the argument that the resistance to the establishment of River Basin Organizations can be overcome by making them representative bodies, I am not sure that the kind of composition that has been proposed (which is quite sound if the `representative' principle is to be followed) will be conducive to effective professional functioning. I am not saying that I differ from the Report on this point, but merely suggesting that further debate on this is necessary.

Sd/-
(Ramaswamy R. Iyer)

LIST OF ANNEXURES

Annexure-1.1

O.M.No. 2/11/96-BM/654

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
Shram Shakti Bhawan, Rafi Marg, New Delhi-110001.

Dated: 13th September,1996

OFFICE MEMORANDUM

Sub: Setting up of a High Powered Commission for Integrated Water Resources Development Plan.

Water is a prime natural resource, a basic human need and a precious national asset. Planing and development of water resources need to be governed by national perspective. Though water resources are abundant, their temporal and spatial distribution on one hand and population on the other, are putting pressure on adequate availability of usable water. The country experiences flood havoc in some areas while at the same time many tracts are reeling under the severity of drought. Excess water in the monsoon is not conserved sufficiently scientifically which after causing misery to millions, flows down unused into the sea. It is, therefore, necessary that scientific development of water resources is taken up considering river basin/sub-basin as a unit. Maximising the availability of utilisable water may involve inter-alia, transfer of water from surplus basin to water-short basin in the overall interest of the country. With proper planning it should be possible to bring about much needed relief and distribute the benefits more evenly.

We need water for different purposes like drinking, irrigation, power generation, navigation, industry and other uses. Integrated Water Resources Development of both, surface and ground water, can optimise benefits resulting in economic use of available water. To achieve this objective, it has been decided by Ministry of Water Resources to set up a High Powered Commission on perspective and operational planning, with the following composition :

1.	Shri G.V.K.Rao Ex-Member, Planning Commission.	:	Chairman
2.	Dr. S.R.Hashim Member, Planning Commission.	:	Member

3.	Shri V.Ramachandran Ex-Chief Secretary, Govt. of Kerala, Trivandrum.	:	Member
4.	Dr. V.S.Vyas (Economist) Director, Institute of Developmental Studies, 8-B, Jhalana Institutional Area, Jaipur-302 004.	:	Member
5.	Dr. D.N.Tiwari Ex-Chancellor, F.R.I.(Deemed University), Dehradun (UP).	:	Member
6.	Shri S.Prakash Ex-Engineer-in-Chief, Delhi Water Supply & Sewage Disposal Undertaking.	:	Member
7.	Shri C.C.Patel Ex-Secretary (WR), Govt. of India.	:	Member
8.	Dr. Bharat Singh Vice- Chancellor (Retd.), University of Roorkee.	:	Member
9.	Shri S.P.Caprihan Engineer-in-Chief (Retd.), Government of M.P.	:	Member
10.	Director General, National Water Development Agency, New Delhi.	:	Convenor

The terms of reference of the Commission are as given below:

i) To prepare an Integrated Water Plan for development of water resources for Drinking, Irrigation, Industrial, Flood Control and Other Uses;

ii) To suggest modalities for transfer of surplus water to water-deficit basins by inter-linking of rivers for achieving the above objectives;

iii) To identify important On-going Projects as well as New Projects which should be completed on priority basis together with phasing;

iv) Identify a technological and interdisciplinary research plan for the water sector with a view to maximise the benefits ;

v) To suggest physical and financial resource generation strategies for the water sector;

vi) Any other related issue.

Other Experts can also be co-opted, if required, to assist the Commission. In addition, the Commission, if it so desires, may obtain the assistance of Central Water Commission, Central Electricity Authority, Planning Commission, Indian Space Research Organisation, National Remote Sensing Agency and other bodies like Inland Waterways Authority of India, National Informatics Centre, National Council for Applied Economic Research etc.

The work may be completed in two years' time.

The administration and finance of the Commission will be as under :

i) The Secretarial services and suitable office space and equipment for the Commission shall be provided by NWDA.

ii) Appropriate Boarding, Lodging, Travel and Transport arrangements will also be made by NWDA and will be free of cost to the Members.

iii) Expenditure involved in all the activities will be met by NWDA from their annual grants.

Sd/-
(C.S. MATHUR)
JOINT COMMISSIONER (BM)
Tel.No. 3714129.

To

All Members of the High Powered Commission etc.

Annexure-1.2

Composition of Various Working Groups of the National Commission for Integrated Water Resources Development Plan

1. Working Group on " Perspective of Water Requirements"

i)	Prof.V.S.Vyas, Ex.Director, Institute of Development Studies, 396, Vasundhara Extn., Gopalpura Bye-Pass, Tonk Road, Jaipur(Rajasthan)-302018.	Chairman
ii)	Sh.R.K.Patel, Ex.Vice- Chancellor, Rajasthan Agricultural University, 92/252, Agrawal Farm, Kshipra Path, Mansarovar, Jaipur.	Member
iii)	Sh.A.S.Kapoor, Chairman, Indira Gandhi Nahar Pariyojana Board, Bhawani Singh Marg, Tilak Nagar, Jaipur(Rajasthan)-302005.	Member
iv)	Sh.T.K.Moulik, CEO, ERM India, A/8,First Floor, Chittaranjan Park, New Delhi-110019.	Member
v)	Sh.Ravi Chopra, Engineer & NGO, Secy. General, Peoples Science Institute Dehradun, 369/1, Vasant Vihar Enclave, Dehradun-248006 (UP).	Member
vi)	Sh.C.S.Hukmani, Ex-Chairman, Brahmaputra Board, 653, Adarsh Nagar, Jaipur(Rajasthan)-302004.	Member

vii) Sh.P.S.Kavdia, — Resource Person
Retd.Secretary,
Indira Gandhi Canal Board,
A-50A,Shastri Nagar, Jaipur-302016.

Dr.C. Ravi was engaged as consultant for the period 01.07.1998 to 30.07.1998(30 days).

2. Working Group on " Water Availability for Use"

i) Dr.S.R.Hashim, — Chairman
Member,
Planning Commission,
Yojana Bhawan, New Delhi.

ii) Sh.R.S. Prasad, — Member
Member (WP&P), CWC,
Sewa Bhawan, 2nd Floor,
R.K. Puram,
New Delhi - 110066

iii) Dr. L.K.Mishra, — Member
Professor, Civil Engineering,
Dean, Planning & Coordination,
University College of Engineering,
Burla, P.O.Burla Engineering College,
Sambalpur (Orissa),
Pin-768018.

iv) Sh.C.L.N.Sastry, — Member
Retd.Secy. Irrigation,
Govt. of Andhra Pradesh,
Flat No.102-7-1-77,
Rajlaxmi Enclave, Dharam Karan Road,
Ameer Pet, Hyderabad-500 016.

v) Shri C.D. Khoche, — Member
Chief Engineer (IMO),
CWC, Sewa Bhawan,
R.K. Puram,
New Delhi0110 066

vi) Sh.S.K.Sharma, — Member
Member,
Survey, Assessment & Monitoring,
Central Ground Water Board,
Jamnagar House, Shahjahan Road,
New Delhi-110011.

vii) Prof.C.P.Sinha, North Eastern Regional Institute of Science & Technology, Nirjuli – 791109 (Itanagar) Arunachal Pradesh. — Member

viii) Sh.R.V.Godbole, Retd.Chief Engineer, CWC, Trikoot-1, 3rd Floor, Bhikaji Cama Place, New Delhi-110066. — Resource Person

3. Working Group on "Water Management for Agriculture, Hydropower, Flood Control and Other Allied Sectors"

i)	Dr. C.C. Patel Ex. Secretary (WR) 91, "Suyog", Sector-19, Gandhinagar (Gujarat).	Chairman
ii)	Shri C.D.Thatte, Ex. Secretary (WR), Secretary General, ICID, Nyaya Marg, New Delhi – 110 021.	Member
iii)	Shri M.U.Purohit, Ex.Secretary , Narmada & Water Resources Department, Govt. of Gujarat, Plot No.287, "Nirant", Sector-20, Gandhinagar-382 020 (Gujarat).	Member
iv)	Shri R.Ghosh, Ex.Chairman, CWC., Consultant, CES, M-215, Sector-25, Jal Vayu Vihar, Noida -201 301 (U.P.).	Member
v)	Shri D.V.Khera, Member (HEP), Central Electricity Authority, Sewa Bhawan, R.K.Puram, New Delhi – 110 066.	Member

vi) Shri M.R.Dighe, Member
Executive Director,
Godavari – Marathawada Irrigation
Development Corporation,
CADA Bhawan, Garkheda Road,
Aurangabad -431 001(Maharashtra).

vii) Shri. M.G. Padhye, Member
Ex. Secretary(WR),
4, Bharat Kunj,
2, Ganesh Nagar Road,
Pune-411 038.

viii) Shri O.N.Bajpai, Member
Ex. Chief Engineer (WR),
Department of Irrigation, Uttar Pradesh,
D-7/7377, Vasant Kunj,
New Delhi.

ix) Shri Muthukumarsamy, Member
Retd. Chief Engineer & Director,
Public Works Department,
Institute for Water Studies,
Taramani, Chennai-600113 (Tamil Nadu).

x) Shri B.N.Navalawala, Member
Advisor (I&CAD),
Planning Commission, Yojana Bhawan,
New Delhi.

xi) Shri C.D.Khoche, Member
Chief Engineer,
Central Water Commission,
R.K.Puram, New Delhi-110066.

xii) Dr. S.P.Sinha Ray, Member
Member (SML),
Central Ground Water Board, NH-IV,
Faridabad-121 001.

xiii) Shri M.R.Gandhi, Resource Person
Retd. Chief Engineer, Govt. of Gujarat,
Plot No.607, Saurabh, Sector-22,
Gandhinagar-382 022(Gujarat).

S/ Shri R.K. Sama and N.P. Singh were engaged as consultants for the periods 15.07.1998 to 03.08.1998(20 days) and 01.09.1998 to 20.09.1998(20 days) respectively.

4. Working Group on " Water Management for Domestic, Industrial and Other Uses"

i)	Shri S. Prakash, Ex. Engineer-in-Chief, Delhi Water Supply & Sewage Disposal Undertaking, 1022, Sector-17B, IFFCO Colony, HUDA, Gurgaon-122001 (Haryana).	Chairman
ii)	Dr. S.R. Sukla, Advisor, Ministry of Urban Development, Nirman Bhavan, New Delhi.	Member
iii)	Dr. S.P. Chakravarty, Member-Secretary, Central Pollution Control Board, Parivesh Bhawan, East Arjun Nagar, New Delhi-110032.	Member
iv)	Dr.K.Mohan, Advisor, Min.of Environment & Forests, Pariyavaran Bhawan, CGO Complex, Phase-II, Lodhi Road,New Delhi-110003.	Member
v)	Sh. V.K. Gupta, Managing Director, U.P. Jal Nigam, Lucknow.	Member
vi)	Shri S. Daivamani, Engineering Director, Madras Metro Water Board, 114, Habibullah Road, T-Nagar, Chennai (Tamil Nadu).	Member
vii)	Shri V. K. Jain, Chairman, M.P.Pollution Control Board, Bhopal (M.P.).	Member
viii)	Sh.N.Kittu, O.S.D (Tech), Rajiv Gandhi Drinking Water Mission, Deptt. of Rural Development, Pariyavaran Bhawan, CGO Complex, Lodhi Road, New Delhi-110003.	Member

ix) Sh.M.L.Kansal, Resource Person
Retd. Chief Engineer,
C-109, Preet Vihar
Delhi-110092.

5. Working Group on "Legal, Institutional & Financing Aspects"

i) Shri V. Ramachandran, Chairman
G-4, Jawahar Nagar,
Thiruvananthapuram – 695014,
Kerala.

ii) Shri Syed Turabul Hassan, Member
Chairman,
Inst. of Research Development &
Social Management,
10-1-123/A/3/1, Saisabad,
Hyderabad (AP).

iii) Shri Kamta Prasad, Member
Professor (Retd.),
Indian Institute of Public
Administration,
B-606, Anand Lok Housing Society,
Mayur Vihar Phase-I,
Delhi-110091.

iv) Shri B.R. Chauhan, Member
Ex. Head,Deptt. Of Law,
Himachal Pradesh University,
M-203, Aruna Cooperative Housing Society,
33, I.P. Extension,
Delhi-110092.

v) Prof. Rahmatullah Khan, Member
Rector, School of International Studies,
Jawaharlal Nehru University,
New Delhi-110067.

vi) Shri S.C. Agarwal, Member
National Council of Applied
Economic Research,
Parisila Bhawan, Indraprastha Estate,
New Delhi-110002.

vii)	Shri Virendra Singh Rekhi, Director, National Law Institute, Q-301, Ansal Lakeview Appartments, Shyamla Hills, Bhopal (M.P.).	Member
viii)	Dr. K. K. Singh, C-233, Indira Nagar, Lucknow-226016 (U.P.).	Member
ix).	Shri R. Vidyasagar Rao, Retd. Commissioner, MOWR, 11-B, Sheikh Sarai Phase-I, New Delhi – 110017.	Resource Person

6. Working Group on " Environmental Aspects"

i)	Dr. D.N. Tewari, Member, Planning Commission & Ex. Chancellor, FRI, 18-A, Auckland Road, Civil Lines, Near Bahuguna Market, Allahabad (U.P.).	Chairman
ii)	Dr. Ram Prasad, Director, Indian Institute of Forest Management, Nehru Nagar, Bhopal-462003 (M.P.).	Member
iii)	Sh. R.N. Mishra, Chief Conservator of Forests, Survey & Forest Conservation Act, Forest Department, Govt. of M.P., 1st Floor, 'A' Wing, Satpura Bhawan, Bhopal (M.P.).	Member
iv)	Sh. B.K.P. Sinha, Chief Conservator of Forest, (Social Forestry), Eastern Zone, Allahabad (U.P.).	Member

v)	Sh. R.L. Java, Ex-Principal Chief Conservator of Forest, No. 1, Rajnagar Society, Behind Gujarat Elecricity Board, Akota Stadium Road, Vadodara -390 015 (Gujarat).	Member
vi)	Dr. S.K. Pandey, G-1, South Civil Lines, Veterinary College Campus, Jabalpur-482 001 (M.P.).	Member
vii)	Dr. V.V. Srinivasan, Ex- Director, 17/1, West Park Road, Ground Floor, Malleshwaram, Bangalore-560 003.	Member
viii)	Sh. Kaushal Kumar, Sociologist, 102, G/3, Beniganj, Allahabad (UP).	Member
ix)	Dr. R.M. Singhal, Project Co-ordinator, IDRC Project, New Forest, Dehradun (UP).	Member
x)	Dr. Mahendra Pal, Head, Botany Division, FRI, P.O. New Forest, Dehradun (UP).	Member
xi)	Dr. Ashok Singh, Ex. Addl. Principal Chief Conservator of Forests, Wildlife, Govt. of U.P., 5- Clive Road, Allahabad - 211001 (UP).	Resource Person

Shri Rakesh Pratap Singh Tomar was engaged as consultant for the period 15.04.1998 to 24.05.1998(40 days).

7. Working Group on " Interbasin Transfer of Water"

i)	Dr.Bharat Singh, Retd.Vice Chancellor, University of Roorkee, 57/1, Civil Lines, Roorkee-247667(U.P.).	Chairman
ii)	Sh.A.D.Mohile, Chairman, Central Water Commission, Sewa Bhawan, R.K. Puram, New Delhi-110 066.	Member
iii)	Prof.M.C.Chaturvedi, Retd.Professor,IIT, 323, Nilgiri Apartments, Alaknanda, New Delhi - 110019.	Member
iv)	Dr.G.N.Padhi, Orissa State Management Consultant, Hydrology Project, Plot No.2132/5124, Nageswar Tangi, Bhubaneswar-751002 (Orissa).	Member
v)	Sh.A.Mohankrishanan, Retd.Chief Engineer (Irrigation), 48, A.K.Block, Annanagar, Chennai-600040 (Tamil Nadu).	Member
vi)	Sh.M.D.Pol, Retd.S.E., Govt.of Maharashtra, 129, Shastri Nagar, Garkheda Road, Aurangabad-431005. (Maharashtra).	Member
vii)	Dr.A.S.Chawla, Ex.Prof.WRDTC, 26,Vishal Apartment, 5, Vasundhara Enclave, Delhi – 110 096.	Resource Person

8. Working Group on " Prioritisation of Ongoing and New Projects Together With Phasing"

i)	Sh. A.D. Mohile, Chairman, CWC, Sewa Bhawan, R.K. Puram, New Delhi-110066.	Chairman
ii)	Sh.B.N.Navalawala, Advisor (I&CAD), Planning Commission, Room No.207, Yojana Bhawan, New Delhi-110001.	Member
iii)	Dr.V.P.Elhence, Ex.Chief Engineer, B-87, Indranagar, Lucknow-226016.	Member
iv)	Sh. Prodipto Roy, Council for Social Development, Sangha Rachana, 53, Lodhi Estate, New Delhi-110003.	Member
v)	Sh.K.P.Gargye, Ex.Chief Engineer, Irrigation Department, Govt. of M.P., C-9, BDA Colony, Shivaji Nagar, Bhopal (M.P.).	Member
vi)	Sh.P.N.Soni, Pr.Scientist (Retd.), IARI, 228-B, DDA MIG Flats, Rajouri Garden, New Delhi.	Member
vii)	Sh. S.S. Manocha Retd. Chief Engineer, CWC, 486, Double Storeyed Building, New Rajinder Nagar, New Delhi – 110060.	Member
vii)	Sh.K.C.Manchanda, Retd.Chief Engineer, CWC, Trikoot-1, 3rd Floor, Bhikaji Cama Place, New Delhi-110066.	Resource Person

Ms. Rekha Bhowmick was engaged as consultant for the period 18.08.1998 to 26.09.1998 (40 days).

9. Working Group on "International Dimensions of Water Planning"

i)	Shri B.G. Verghese Research Professor, Centre for Policy Research, Dharma Marg, Chanakyapuri, New Delhi.	Chairman
ii)	Shri R.B. Shah Ex-Chairman, CWC, M-61, Swati Apartments, No.12, Patparganj, I.P. Extension, Delhi-110 092.	Member
iii)	Shri T. Prasad, Professor of Civil Engineering & Director, Centre for Water Resources Studies, Patna University, Patna – 800005.	Member
iv)	Sh. Dipankar Basu, Chairman, Inland Waterways Authority of India, B/109-112, Commercial Complex, Sector-18, Noida (UP).	Member
v)	Shri Arbinda Ghose, Formerly with Hindustan Times, G-201, Nanakpura, New Delhi-110 021.	Member
vi)	Dr. P.S. Rao, Joint Secretary, Legal and Treaties Division, Ministry of External Affairs, V/3/17, Lodhi Complex, New Delhi.	Member
vii)	Shri R. Rangachari, Ex-Member, CWC, M-31, Swati Apartments, 12, Patparganj, I.P. Extension, Delhi-110 092.	Member

viii)	Shri N.V.V. Char, Commissioner (Retd.),MOWR, A-12 C, Munirka, DDA Flats, New Delhi-110 067.	Member
ix)	Shri M.S. Menon, Retd. Chief Engineer,CWC, 30, Ganga Apartments, Alaknanda, New Delhi.	Resource Person

Annexure-1.3

Terms of Reference of Various Working Groups of the National Commission for Integrated Water Resources Development Plan

1. Working Group on "Perspective of Water Requirements"

Terms of Reference

1. To assess the consumptive and non-consumptive domestic requirement and population for mega cities, other cities and rural areas for 2010,2025 & 2050.

2. To obtain information on present status of per capita requirement of water in various States for domestic, bovine and industrial needs for urban and rural areas and separately for large cities along with present and expected population in 2010, 2025 & 2050.

3. To decide the high priority basic minimum requirements and suggest the norms, which need to be provided for as a basic right or for minimum support for life.

4. To obtain information about area irrigated and assess area likely to be brought under irrigation by 2050 AD(Statewise and basinwise).

5. To obtain information on essential needs of water for navigational development in the country at present and assess needs upto 2050 AD.

6. To obtain information for consumptive needs of hydropower development upto 2050 AD, as also on the quantity of hydropower draft non-compatible with other uses, such as tail race discharges near the coast.

7. To have information for essential environmental needs of water at present and upto 2050 AD.

8. To obtain information about norms being used for above uses for planning purposes by States, if any.

9. To examine the norms vis-à-vis the norms in other countries in the subcontinent, norms suggested by Ministry of Urban Development, Bureau of Indian Standards, CWC, Inland Waterways Authority of India, CEA and Ministry of Environment and Forests and suggest norms for adoption in the country considering expected socio-economic development, industrialisation, improvement in living and health standards.

10. The group would attempt a country wide assessment, as well as its segregation basinwise and Statewise.

11. Any other related issues.

2. Working Group on "Water Availability for Use"

Terms of Reference

1. To assess the natural availability of surface water, ground water in deep acquifers & fossil water both as dynamic flows and static resource basinwise and Statewise.

2. To assess the ground water recharge and ground water parameters connected with surface flows.

3. To assess utilisable flows from surface water as well as ground water basinwise and Statewise.

4. To assess/suggest the probable utilisable surface water and ground water for consumptive use.

5. To assess the possibilities of large utilisation through water harvesting, induced percolation through percolation tanks, hydro-fracturing etc. as also renovation of small tanks and traditional structures, encouraging roof top harvesting & recycling of water.

6. To obtain information about Statewise/basinwise utilisation of water for irrigation, hydropower and other uses at present and in future upto 2025 AD.

7. To assess desalinisation as a supply possibility.

8. Keeping in view the existing technology, to suggest research and development requirements for augmenting available supplies.

9. Sedimentation of reservoirs and its impact on water availability.

10. Any other related issues.

3. Working Group on "Water Management for Agriculture, Hydropower, Flood Control and Other Allied Sectors"

Terms of Reference

1. To identify and assess the irrigable areas by surface water and ground water respectively basinwise and Statewise.

2. To collect information on present agricultural practices in the country and the water uses.

3. To suggest ways and means to discourage practices involving wasteful use of water in irrigation and encourage water saving methods.

4. To study low cost improved irrigation methods such as furrows, surges etc. and high cost irrigation mechanical methods and make suitable recommendations. To recommend public awareness programmes and field extension approaches.

5. To consider management practices and possibilities with particular emphasis on allocation of water amongst the users either as per the cropping pattern or as a fixed quantum/ha.

6. To study the methods of operation of secondary system with (i) minimum control and (ii) full control and suggest appropriate methods.

7. To assess the possibility of automation of operation of main canals.

8. To study and recommend the extent of the conveyance system to be handed over to the Water Users' Associations.

9. To consider whether water should be made available per capita or land holding basis and study the issue of water rates.

10. To assess the efficiency of conveyance of delivery system and recommend research and development needs in this sector.

11. To assess the areas affected by water logging and salinity and suggest methods for improving the irrigability of such areas.

12. To review and suggest changes in the institutional structures for agricultural water use including participatory irrigation management.

13. To have information on pricing structure of water Statewise and make suitable recommendations.

14. To study the problem of water logging and drainage in irrigated areas and assess requirement of drainage system in the existing, ongoing and future projects.

15. To collect information on projected, ongoing and new projects and their phasing and prioritisation.

16. To decide additional recharge in the command due to water loss in the network and field application.

17. To study the possibilities of large scale micro water shed development in the country especially in the drought prone areas for sustaining atleast one crop - for multipurpose uses such as irrigation, prevention of soil erosion, afforestation etc.

18. To make recommendations on optimising conjunctive use with surface and ground water.

19. To assess the potential and prospects of hydropower development and the methods of accelerating the hydropower availability and recommend strategies and policies to be framed for speedy development of hydropower, suggest ideas for hydro thermal mix etc.

20. Assessment of availability of hydropower by inter-basin water transfer in future.

21. To assess the compatibility and/or conflict between hydropower generation and agricultural requirement.

22. To assess the unutilised potential due to tail water discharges in the coastal regions and to suggest measures for utilising these waters.

23. To evaluate the effectiveness of various flood control measures adopted so far and their effectiveness and to suggest further measures to accelerate the programmes, prioritise the affected regions, future strategies to safeguard against the damage to life and property by floods.

24. To examine preparation of flood zone and land zone maps and need for adopting appropriate control measures for limiting development in flood prone areas. To examine possibility of introducing crop insurance against floods instead of flood relief measures.

25. To study economics of providing flood space in new reservoirs, flood proofing and flood plain zoning and management to prepare action plan for fighting the disaster of floods caused by natural calamities and man made intervention.

26. Any other related issues.

4. Working Group on "Water Management for Domestic, Industrial and Other Uses"

Terms of Reference

1. To assess the consumptive and non-consumptive domestic requirement and population for mega cities, other cities and rural areas for 2010, 2025 & 2050.

2. To suggest measures for minimising water requirement for consumptive uses in water short areas and to suggest drill of reducing consumption of domestic water in years of low availability. Suggest ways for implementation of these through community involvement.

3. To consider social/political constraints in present pricing policies and suggest ways and means of resources generation under Indian social and economic conditions.

4. To study the prevalent norms of domestic water requirement and to suggest core needs attracting priority and non core needs not requiring priority.

5. To assess line losses (water not used) and commercial losses (Water used but not accounted for), and to decide the practicable lower limits on these, and ways of achieving these limits.

6. To suggest the standard of sewage to be allowed in sewerage, storm water drainage.

7. To suggest the institutions/bodies which would bear the costs of the sewage treatment and modes for raising the funds for this purpose which may include some self paying innovative ideas like combination of oxidation tank with safety tanks and with advantages of subsequent pisiculture and to examine the possibilities of using low cost system of oxidation ponds combined with pisiculture for sewage treatment.

8. To suggest various research and development needs for improving the quantity and quality of water requirement for domestic purposes.

9. People's participation in rural water supply schemes through voluntary organisations.

10. To assess the possibility of self generation of funds for rural water supply & reduction of grants and involving Panchayats in such issues.

11. To obtain information on present water use, quantum of waste and toxic discharges in various industries.

12. To assess the possibility and extent of reuse of water in industries and possibility of insisting on zero effluent condition while allowing hazardous industries in semi and arid areas.

13. To suggest the norms for supply of different qualities of water to various industries, so that good quality water is not used for inferior purposes and to suggest strategies for reducing industrial use of water.

14. To study the economies of treating toxic discharges and desirability of having deterrent measures.

15. To assess the research and development needs for minimizing water use, improving the quality of waste water, toxic discharges etc.

16. To assess possibilities of social forestry or disposal on land to eliminate hazardous industrial effluents, and possible long term effect of these on ground water.

17. Any other related issues.

5. Working Group on "Legal, Institutional and Financing Aspects"

Terms of Reference

1. To examine the possibility of private financing of water projects, through different types of Management Schemes, the legal aspects of such participation, financial sustainability of such schemes etc.

2. To obtain information on present status of role/involvement of peoples' institutions, private sector, co-operative sector in water development and management, water distribution, collection of water rates etc.

3. To examine the feasibility/desirability of involving private/Cooperative participation and limits there of.

4. To assess the essential sphere of responsibility of Government with regard to items like land acquisition which private agencies may not be able to handle.

5. To suggest measures to build up confidence in private developers, to ensure that political changes would not cause impediments.

6. To suggest a policy for involving and assisting Voluntary/Co-operative agencies for promotion of farmers participation in water resources sector.

7. To assess the possibility & desirability of joint sector management of water projects, through the Government, private parties and water users' associations contributing to the equity.

8. To prepare working paper on the above aspects after getting inputs from various Central Organisations and State Governments for consideration of the Core Working Group.

9. Review of existing institutional and organisational structure in relation to water in Government, Cooperative and Private Sector.

10. To suggest changes in personnel policies and cadre management in encouraging professionalism, training and education as also possibility of inducting personnel directly at various higher levels.

11. To suggest a programme for both improved management and expansion of water development.

12. To assess the possibility of restructuring in Indian water sector institutions towards consolidation, internalisation of concerned and interdisciplinary working and providing for user's participation.

13. To assess the possibility of setting up independent autonomous and largely self finance institution for basin management and water sector performance analysis etc.

14. To assess the physical and financial resource generation for water resources projects.

15. To assess the possibility of support and guidance of international donors and the Union Government to act as important motivation factors for the necessary changes in the water resources sector.

16. To assess the changes needed in the legal aspects of water rights of individuals, communities and States.

17. To examine the constitutional provisions pertaining to water sector in general and article 262 by 17-list II and entry 56-list I in particular and suggest guidelines for meeting the requirements by various interstate groups in future.

18. To suggest the legal and administrative steps for regulation of ground water so as to maintain desirable depths in areas of over exploitation.

19. To examine and suggest any modification in the model bill for the ground water.

20. To suggest legal and administrative means for minimising the toxic discharge of industrial waste.

21. To suggest the legal and administrative measures for regulating the ground water quality as affected from surface water containing fertilisers, pesticides and insecticides.

22. To review the prevalent water market in various regions and to suggest its continuance or otherwise.

23. To review the framework of interstate sharing of water.

24. To examine the issues pertaining to financing of Water Resources Projects.

25. Any other related issues.

6. Working Group on "Environmental Aspects"

Terms of Reference

1. To assess the information about the forest area submerged by storages already created and likely to be created in future, the consequent loss of biomass as also the consequent new biomass created through irrigation.

2. To collect the information regarding rehabilitation & resettlement of oustees as well as soil & water conservation aspects with due respect to afforestation programme both along the water distribution system and other suitable areas.

3. To obtain information on ecologically sensitive and biologically rich regions for total protection & demarcation of critically degraded areas requiring priority treatment.

4. To evaluate the present development mix alongwith formation of environmental management plans for prevention or mitigation of adverse impacts from the development projects both existing and those in the pipeline.

5. To assess environmental impact of large projects and interbasin water transfer links.

6. To obtain information about water logging, salination, sedimentation of reservoirs and sedimentation of distribution network.

7. To examine if losses of diversity in plant life through large irrigation projects constitute ecological risks.

8. To examine the role of irrigation paddy as a contributor of green house gases.

9. Need for internalisation of environmental concerns within water resources institutions, instead of having separate institutions for developmental and environmental concerns, apparently working at cross purposes.

10. To suggest norms for the quantification of the environmental costs and benefits with and without project development.

11. To evolve criteria for improving sustainability of water resources projects.

12. To assess the economic value of environmental action and attempt to quantify the intangibles.

13. To establish environmental management systems, create reliable environmental data base and eco-systems, rehabilitation as well as strengthening the institutional support.

14. To assess the minimum flow requirements downstream of water resources structures for maintaining the ecological balance.

15. To identify various activities causing surface water & ground water pollution and suggest the suitable controlling measures.

16. To collect information about the positive & negative environmental impacts of water resources projects in India and abroad.

17. To assess the information on management of wetland systems & mangrove, coastal land for sustainable development.

18. To assess water quality, water borne diseases, health and dam safety.

19. To assess the need of having transparency and public hearings for developmental projects.

20. Any other related issues.

7. Working Group on "Inter-basin Transfer of Water"

Terms of Reference

1. To assess the availability of water in each river basin, its potential use for sustainable development, and transfer, if there is any surplus available.

2. To evaluate the modalities of interbasin transfer, the need for storage, the conveyance links, and other hydraulic structures and their phasing.

3. To study the need for enabling legal instruments including, if necessary, constitutional amendment for implementation taking into account existing interstate accords, tribunal decisions and to review the role of the Union Government in interbasin transfer particularly to non-basin States.

4. To evaluate the economic viability of interbasin transfer, to suggest guidelines for economic analysis and allocation of costs and benefits to different components.

5. To assess the socio-economic and environmental impact due to interbasin transfer including R & R requirement.

6. To study the possibility of private funding and soft loans, from international agencies for implementation of interbasin water transfer, considering their primary role in providing food & employment and thus maintaining regional tranquility.

7. Need for future research.

8. Working Group on "Prioritisation of Ongoing and New Projects Together with Phasing"

Terms of Reference

1. To have information and recommend guidelines for prioritisation of ongoing projects considering the following:

   (a) Limitations of the availability of finance and to make reasonable projection for future financial requirements.

   (b) Need for prioritising projects nearing completion and to recommend the procedure so that the benefit starts showing at the earliest.

   (c) The financial problems of the projects because of inadequate financing, consequent delays which lead further to increase of residual cost due to inflation and increase of interest rate etc.

   (d) Need felt by State Governments to maintain regional balances in regard to spending money in projects.

(e) Need for completing projects giving substantial domestic water supply benefits on higher priority.

(f) Need felt by State Governments to complete some projects on priority, in view of interstate aspects.

2. To evaluate the possibilities of phasing projects to that ponding the reservoirs only when it becomes possible to use the spread water, thus reducing sedimentation.

3. To discuss, how, phasing of a project for early start of irrigation in head reaches with plentiful waters should not lead to problems like water logging, changes in cropping pattern which are difficult to correct, and larger maintenance problems on main canal flowing with a small discharge (learning from Sri Ram Sagar and Indira Gandhi Nahar Pariyojana phase-I).

4. To review the need for pilot and experimental crops being watered by ground water till the storage project comes up, to help in phasing and quick development.

5. To recommend guidelines about the overdraining of ground water in the command of the project which is under construction, before surface water irrigation starts, and allow rebuilding of ground water later on.

6. To recommend the methodology to be adopted for phasing of hydropower projects so that, with suitable rating of design head, the powerhouse can start functioning with partial ponding.

7. Any other related issues.

9. Working Group on "International Dimensions of Water Planning"

Terms of Reference

1. Need for/possibilities of cross-border cooperation in : (a) environmental protection measures, conservation of scarce natural resources, maintenance of water quality, preservation of wetlands, etc; (b) flood/disaster preparedness, management and mitigation of damage ; (c) promotion of inland water transport.

2. The looming global water shortage in relation to population growth and sustainability.

3. Cooperation in the generation/sharing/processing of data and information relating to all of the above.

4. Possibilities of enhancing the usefulness and effectiveness of national planning through coordinated planning across borders; possibilities of cooperation in water resources development, management, utilisation and conservation, including joint projects / programmes where feasible and desirable.

5. Relations with neighbouring countries in the area of water resources, and their bearing on national planning, keeping in mind the desirability of optimising benefits, avoiding conflicts of interests, and ensuring fairness, equity and no harm to any party.

6. Emerging international water law (e.g. the International Law Commission's draft now before the United Nations), Conventions and basin agreements, e.g. Mekong.

7. Any other related issues.

Annexure-1.4

Composition of Sub-Groups for Working Group on "Water Management for Agriculture, Hydropower, Flood Control and Other Allied Sectors"

Sub-Group No.	Subject	Name of the Convenor & Members of the Sub-Group
I.	Water Management	**Convenor:** Shri M.G.Padhye, 4, Bharat Kunj, 2 Ganesh Nagar Road, Pune – 411 038. **Members:** i. Sh. B.N. Navalawala, Adivisor(I&CAD), Planning Commission, 207, Yojana Bhawan, New Delhi. ii. Sh. C.D. Khoche, Chief Engineer(IMO), Central Water Commission, Sewa Bhawan, R.K. Puram, New Delhi. iii. Shri M.R.Dighe, Executive Director, Godavari – Marathawada Irrigation Development Corporation, CADA Bhawan, Garkheda Road, Aurangabad -431 001, Maharashtra. iv. Shri Muthukumarsamy, Retd.Chief Engineer & Director, Public Works Department, Institute for Water Studies, Taramani, Chennai-600113, Tamil Nadu.

v. Sh. O.T. Gulati,
Chief Engineer(CAD) &Jt. Secretary, Narmada and Water Resources Deptt., Block No.9, 2nd Floor, New Sachivalaya, Gandhinagar-382010.

vi. Sh. P.B.S. Sarma,
Ex-Director,
Water Technology Centre,
IARI, Pusa Road,
New Delhi-110012.

II. Canal Automation

Convenor:

Sh. A.B. Mandavia,
Chief Engineer & Director,
WALMI, Anand(Gujarat).

Members:

i. Sh. P.M. Soni,
Chief Engineer, Sardar Sarovar Narmada Nigam Ltd.,
Block No.-12,
New Sachivalaya,
Gandhinagar-382010.

ii. Sh. H.K. Pasarate,
Superintending Engineer,
Jayakwadi Project Circle,
Aurangabad,
Maharashtra.

iii. Sh. S.B. Kulkarni,
Joint Director,
CWPRS, Post-Khadakvasla,
Pune-411024.

iv. Sh.R.D. Sharma,
Chief Engineer, CAD,
Indira Gandhi Nahar Project,
Bikaner(Rajasthan).

III. Equitable Distribution & Water Users' Participation

Convenor:

Shri O.N. Bajpai,
Retd.Chief Engineer,
Department of Irrigation,UP,
C-9/9272 Vasant Kunj,
New Delhi

Members:

i. Sh. M.A. Bandi,
Chief Engineer(MI) & Jt.Secretary, Narmada & WaterResources Deptt., Block No.9,New Sachivalaya,
Gandhinagar – 382010.

ii. Sh. A.N. Mistry,
Director and Chief Engineer,
Water and Land Management Institute, Post Box No.80,
Anand(Gujarat).

IV. Water Logging & Drainage

Convenor:

Shri C.D.Thatte,
Secretary General, ICID,
Nyaya Marg, New Delhi–110 021.

Members :

i. Dr.N.K. Tyagi,
Director,
Central Soil Salinity Research Institute,
Karnal-132001(Haryana).

ii. Sh.T.P. Mathur,
Project Manager,
Rajad Project, CAD Building,
P.O.Box No.112,
New Green Mandi,
Kota-324007(Rajasthan).

iii. Shri P. B. S. Sarma,
Ex-Director,
Water Technology Centre,
IARI, Pusa Road,
New Delhi-110012.

iv. Sh. O.T. Gulati,
Chief Engineer(CAD) &Jt. Secretary, Narmada & Water Resources Deptt., Block No.9, 2nd Floor, New Sachivalaya, Gandhinagar-382010.

V. Flood Control

Convenor:

Shri R. Ghosh,
M-215, Sector-25,
Jal Vayu Vihar,
Noida-201301.

Members:

i. Sh.B.P. Singh,
Member,
Ganga Flood Control Commission,
Sichai Bhawan, Patna-800015.

ii. Sh. S.K. Chakravorty,
Chief Engineer (P&D),
Brahmaputra Board, Basista,
Guwahati-28.

iii. Sh. A.N.K. Singh,
Chief Engineer, Flood and Delta,
Office of the Engineer-in-Chief,
Secha Bhawan,
Bhubaneswar-751001(Orissa).

VI. Pricing of Water & Micro Watershed Development

Convenor:

Shri M.U.Purohit,
Ex-Secretary,
Narmada & Water Resources, GOG, Plot No.287,"Nirant", Sector-20,
Gandhinagar-382020.

Members:

i. Dr. D. Ramakrishnaiah,
Deputy Commissioner(DPAP),
Ministry of Rural Areas and Employment, Block No.11,
6th Floor, CGO Complex,
Lodhi Road, New Delhi – 110003.

ii. Sh.P.C. Bodh,
Director(WRE),
Central Water Commission,
Room No.901(S), Sewa Bhawan,
R.K.Puram, New Delhi-110066.

iii. Sh.Gajendra Singh Chaudhari,
Chief Engineer,
Irrigation Department,
Government of Rajasthan,
Sinchai Bhawan,
Bhavani Singh Marg,
Jaipur-302004.

VII. (a) Hydro Power

Convenor :

Sh.D.V. Khera,
Member(HEP),Central Electricity
Authority, Sewa Bhawan, R.K.Puram,
New Delhi- 110066.

Members:

i. Shri O.N. Bajpai,
Retd.Chief Engineer,
Department of Irrigation,UP,
C-9/9272 Vasant Kunj,
New Delhi.

ii. Sh.Suresh Agrawal,
Principal Scientific Officer,
Ministry of Non-Conventional
Energy Sources,
Govt. of India, New Delhi.

(b) National Rehabilitation Policy

Convenor :

Shri M. G.Padhye,
4, Bharat Kunj,
2, Ganeshnagar Road,
Pune-411038.

Members:

i. Sh.N.B.Desai,
Secretary(Narmada),
Sardar Sarovar Narmada Nigam Ltd.,
Block No.12, New Sachivalaya,
Gandhinagar – 382010(Gujarat).

ii. Sh.V.K. Babbar,
Rehabilitation Commissioner,
Chief Executive Officer,
S.S. Rehabilitation Agency,
Vadodara.

VIII. Ground Water including Conjunctive Use

Convenor :

Shri Muthukumarsamy,
Retd.Chief Engineer &
Director, Institute for
Water Studies, Taramani ,
Chennai-600113.

Members:

i. Dr. S.P. Sinha Ray,
Member(SML), CGWB, NH-IV,
Faridabad-121001.

ii. Sh. A.S. Chawla,
26, Vishal Apartment,
5, Vasundhara Enclave,
Delhi – 110096.

Annexure – 1.5

List of Officers of the Secretariat of the National Commission for Integrated Water Resources Development Plan

Officers:

1.	Shri A.D.Mohile (13-9-1996 to 15-4-1997)	Director General, NWDA
2.	Shri Z. Hasan (16-4-1997 to 9-2-1998)	Director General, NWDA
3.	Shri B.K. Mittal (10-2-1998 to 7-5-1998)	Director General, NWDA
4.	Shri R.K. Parashar (8-5-1998 onwards)	Director General, NWDA
5.	Shri S.B. Suri	Chief Engineer, NWDA
6.	Shri B.M. Jha	Director, CGWB
7.	Shri Rajesh Kumar (Upto 30-6-1999)	Director, NWDA
8.	Shri P.R. Chopra	Director (Technical), NWDA
9.	Shri A.K. Sharda	Scientist (Soils), NWDA
10.	Shri K.P. Gupta	Director, NWDA
11.	Shri S.C. Awasthi	Deputy Director, NWDA
12.	Shri J.S. Taneja	Deputy Director, NWDA
13.	Shri K.K. Bansal	Deputy Director, NWDA
14.	Shri V.K. Sharma (Upto 17-2-1998)	Deputy Director, NWDA
15.	Shri S.K. Sinha	Assistant Director, NWDA
16.	Shri R.K. Kharbanda	Assistant Director, NWDA
17.	Shri K.K. Rao	Assistant Engineer, NWDA
18.	Shri H.D. Kumar(Upto 20-7-1998)	Assistant Engineer, NWDA
19.	Shri T.M. Sampath	PS to Director General, NWDA
20.	Shri Sushil Kumar (19-8-1998 onwards)	Stenographer Gr.I

Supporting Staff:

1.	Shri N.J. Sarode	Stenographer Gr.II, NWDA
2.	Shri Dalip Singh	Stenographer Gr.II, NWDA
3.	Shri M. Satyanarayana	Stenographer Gr.II, NWDA
4.	Shri Rajpal Arora	Stenographer Gr.III, NWDA
5.	Shri Kamaljeet Chauhan	D'man Gr.III, NWDA
6.	Shri A.P. Patra	U.D.C., NWDA
7.	Shri Nanak Chand	L.D.C., NWDA
8.	Shri Mukesh Kumar	L.D.C., NWDA

Annexure-2.1

NATIONAL WATER POLICY, 1987

The Need for a National Water Policy

1.1 Water is a prime natural resource, a basic human need and a precious national asset. Planning and development of water resources need to be governed by national perspectives.

1.2 It has been estimated that out of the total precipitation of around 400 million hectare metres in the country, the surface water availability is about 178 million hectare metres. Out of this, about 50% can be put to beneficial use because of topographical and other constraints. In addition, there is a ground water potential of about 42 million hectare metres. The availability of water is highly uneven in both space and time. Precipitation is confined to only about three or four months in the year and varies from 10cm in the western parts of Rajasthan to over 1000 cm at Cherrapunji in Meghalaya. Further, water does not respect state boundaries. Not merely rivers but even underground aquifers often cut across state boundaries. Water as a resource is one and indivisible : rainfall, river waters, surface ponds and lakes and ground water are all part of one system; water is also a part of a larger ecological system.

1.3 Floods and drought affect vast areas of the country, transcending state boundaries. A third of the country is drought-prone. Floods affect an average area of around 9 million hectares per year. According to the National Commission on floods, the area susceptible to floods is around 40 million hactares. The approach to the management of drought and floods has to be coordinated and guided at the national level.

1.4 Even the planning and implementation of individual irrigation or multi-purpose projects, though done at the State level, involve a number of aspects and issues such as environmental protection, rehabilitation of project-affected people and livestock, public health consequences of water impoundment, dam safety etc. On these matters common approaches and guidelines are necessary. Moreover, certain problems and weaknesses have affected a large number of projects all over the country. There have been substantial time and cost overruns on projects. In some irrigation commands, problems of water logging and soil salinity have emerged, leading to the degradation of good agricultural land. There are also complex problems of equity and social justice in regard to water distribution. The development and exploitation of the country's groundwater resources also give rise to questions of judicious and scientific resource management and conservation. All these questions need to be tackled on the basis of common policies and strategies.

1.5 The growth process and the expansion of economic activities inevitably lead to increasing demands for water for diverse purposes: domestic, industrial, agricultural, hydro-power, navigation, recreation etc. So far, the principal consumptive use of water has been for irrigation. While the irrigation potential is estimated to have increased from 19.5 million hectares at the time of Independence to about 68 million hectares at the end of the Sixth Plan, further development of a substantial order is necessary if the food and fibre needs of a growing population are to be met. The country's population which is over 750 million at present is expected to reach a level of around 1000 million by the turn of the century.

1.6 The production of foodgrains has increased from around 50 million tonnes in the fifities to about 150 million tonnes at present, but this will have to be raised to around 240 million tonnes by the year 2000 A.D. The drinking water needs of people and livestock have also to be met. In keeping with the objectives of the international Drinking Water Supply and Sanitation Decade Programme (1981-1991), adequate drinking water facilities have to be provided to the entire population in both urban and rural areas and sanitation facilities to 80% of the urban population and 25% of the rural population by the end of the decade. Domestic and industrial water needs have largely been concentrated in or near the principal cities, but the demand from rural society is expected to increase sharply as the development programmes improve economic conditions in the rural areas. The demand for water for hydro and thermal power generation and for other industrial uses is also likely to increase substantially. As a result, water which is already a scarce resource will become even scarcer in future. This underscores the need for the utmost efficiency in water utilization and a public awarensss of the importance of its conservation.

1.7 Another important aspect is water quality. Improvements in existing strategies and the innovation of new techniques resting on a strong science and technology base will be needed to eliminate the pollution of surface and ground water resources, to improve water quality and to step up the recycling and re-use of water. Science and technology and training have also important roles to play in water resources development in general.

1.8 Water is one of the most crucial elements in developmental planning. As the country prepares itself to enter the 21st century, efforts to develop, conserve, utilise and manage this important resource have to be guided by national perspectives. The need for a national water policy is thus abundantly clear; water is a scarce and precious national resource to be planned, developed and conserved as such, and on an integrated and environmentally sound basis, keeping in view the needs of the States concerned.

Information System

2. The prime requisite for resource planning is a well-developed information system. A standardised national information system should be established with a network of data banks and data bases, integrating and strengthening the existing Central and State level agencies and improving the quality of data and the processing capabilities. There should be free exchange of data among the various agencies and duplication in data collection should be avoided. Apart from the data regarding water availability and actual water use, the system should also include comprehensive and reasonably reliable projections of future demands for water for diverse purposes.

Maximising Availability

3.1 The water resources available to the country should be brought within the category of utilizable resources to the maximum possible extent. The resources should be conserved and the availability augmented by measures for maximising retention and minimising losses.

3.2 Resources planning in the case of water has to be done for a hydrological unit such as a drainage basin as a whole, or for a sub-basin. All individual developmental projects and proposals should be formulated by the States and considered within the framework of such an overall plan for a basin or sub-basin, so that the best possible combination of options can be made.

3.3 Appropriate organisations should be established for the planned development and management of a river basin as a whole. Special multi-disciplinary units should be set up in each state to prepare comprehensive plans taking into account not only the needs of irrigation but also harmonising various other water uses, so that the available water resources are determined and put to optimum use having regard to subsisting agreements or awards of Tribunals under the relevant laws.

3.4 Water should be made available to water short areas by transfer from other areas including transfer from one river basin to another, based on a national perspective, after taking into account the requirements of the areas/basins.

3.5 Recycling and re-use of water should be an integral part of water resource development.

Project Planning

4.1 Water resource development projects should as far as possible be planned and developed as multipurpose projects. Provision for drinking water should be a primary consideration. The projects should provide for irrigation, flood mitigation, hydro-electric power generation, navigation, pisciculture and recreation, wherever possible.

4.2 The study of the impact of a project during construction and later on human lives, settlements, occupations, economic and other aspects should be an essential component of project planning.

4.3 In the planning, implementation and operation of projects, the preservation of the quality of environment and the ecological balance should be a primary consideration. The adverse impact, if any, on the environment should be minimised and should be off-set by adequate compensatory measures.

4.4 There should be an integrated and multi-disciplinary approach to the planning, formulation, clearance and implementation of projects, including catchment treatment and management, environmental and ecological aspects, the rehabilitation of affected people and command area development.

4.5 Special efforts should be made to investigate and formulate projects either in, or for the benefit of, areas inhabited by tribal or other specially disadvantaged groups such as Scheduled Castes and Scheduled Tribes. In other areas also, project planning should pay special attention to the needs of Scheduled Castes and Scheduled Tribes and other weaker sections of society.

4.6 The planning of projects in hilly areas should take into account the need to provide assured drinking water, possibilities of hydro-power development and the proper approach to irrigation in such areas, in the context of physical features and constraints such as steep slopes, rapid run-off and the incidence of soil erosion. The economic evaluation of projects in such areas should also take these factors into account.

4.7 Time and cost overruns and deficient realization of benefits characterising most irrigation projects should be overcome by upgrading the quality of project preparation and management. The under-funding of projects should be obviated by an optimal allocation of resources, having regard to the early completion of on-going projects as well as the need to reduce regional imbalances.

Maintenance and Modernisation

5.1 Structures and systems created through massive investments should be properly maintained in good health. Appropriate annual provisions should be made for this purpose in the budgets.

5.2 There should be a regular monitoring of structures and systems and necessary rehabilitation and modernisation programmes should be undertaken.

Safety of Structures

6. There should be proper organisational arrangements at the national and state levels for ensuring the safety of storage dams and other water-related structures. The Central guidelines on the subject should be kept under constant review and periodically updated and reformulated. There should be a system of continuous surveilliance and regular visits by experts.

Ground Water Development

7.1 There should be a periodical reassessment on a scientific basis of the ground water potential, taking into consideration the quality of the water available and economic viability.

7.2 Exploitation of ground water resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. Ground water recharge projects should be developed and implemented for augmenting the available supplies.

7.3 Integrated and coordinated development of surface water and ground water and their conjunctive use, should be envisaged right from the project planning stage and should form an essential part of the project.

7.4 Over exploitation of ground water should be avoided near the coast to prevent ingress of sea water into sweet water aquifers.

Water Allocation Priorities

8. In the planning and operation of systems, water allocation priorities should be broadly as follows :

- Drinking water
- Irrigation
- Hydro-power
- Navigation
- Industrial and other uses.

However, these priorities might be modified if necessary in particular regions with reference to area specific considerations.

Drinking Water

9. Adequate drinking water facilities should be provided to the entire population both in urban and in rural areas by 1991. Irrigation and multipurpose projects should invariably include a drinking water component, wherever there is no alternative source of drinking water. Drinking water needs of human beings and animals should be the first charge of any available water.

Irrigation

10.1 Irrigation planning either in an individual project or in a basin as a whole should take into account the irrigability of land, cost-effective irrigation options possible from all available sources of water and appropriate irrigation techniques. The irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximise production.

10.2 There should be a close integration of water-use and land-use policies.

10.3 Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between head-reach and tail end farms and between large and small farms should be obviated by adoption of a rotational water distribution system and supply of water on a volumetric basis subject to certain ceilings.

10.4 Concerted efforts should be made to ensure that the irrigation potential created is fully utilised and the gap between the potential created and its utilisation is removed. For this purpose, the command area development approach should be adopted for all irrigation projects.

Water Rates

11. Water rates should be such as to convey the scarcity value of the resource to the users and to foster the motivation for economy in water-use. They should be adequate to cover the annual maintenance and operation charges and a part of the fixed costs. Efforts should be made to reach this ideal over a period, while ensuring the assured and timely supplies of irrigation water. The water rates for surface water and ground water should be rationalised with due regard to the interests of small and marginal farmers.

Participation of Farmers and Voluntary Agencies

12. Efforts should be made to involve farmers progressively in various aspects of management of irrigation systems, particularly in water distribution and collection of water rates. Assistance of voluntary agencies should be enlisted in educating the farmers in efficient water use and water management.

Water Quality

13. Both surface water and ground water should be regularly monitored for quality. A phased programme should be undertaken for improvements in water quality.

Water Zoning

14. Economic development and activities including agricultural, industrial and urban development, should be planned with due regard to the constraints imposed by the configuration of water availability. There should be a water zoning of the country and the economic activities should be guided and regulated in accordance with such zoning.

Conservation of Water

15. The efficiency of utilisation in all the diverse uses of water should be improved and an awareness of water as a scarce resource should be fostered. Conservation consciousness should be promoted through education, regulation, incentives and disincentives.

Flood Control and Management

16. There should be a master plan for flood control and management for each flood prone basin. Sound watershed management through extensive soil conservation, catchment area treatment, preservation of forests and increasing the forest area and the construction of check-dams should be promoted to reduce the intensity of floods. Adequate flood-cushion should be provided in water storage projects, wherever feasible, to facilitate better flood management. An extensive network for flood forecasting should be established for timely warning to the settlements in the flood plains, along with the regulation of settlements, land and economic activity in the flood plain zones, to minimise the loss of life and property on account of floods. While physical flood protection works like embankments and dykes will continue to be necessary, the emphasis should be on non-structural measures for the minimisation of losses, such as flood forecasting and warning and flood plain zoning, so as to reduce the recurring expenditure on flood relief.

Land Erosion by Sea or River

17. The erosion of land, whether by the sea in coastal areas or by river waters inland, should be minimised by suitable cost-effective measures. The States and Union territories should also undertake all requisite steps to ensure that indiscriminate occupation and exploitation of coastal strips of land are discouraged and that the location of economic activities in areas adjacent to the sea is regulated.

Drought Management

18.1 Drought-prone areas should be made less vulnerable to drought-associated problems through soil-moisture conservation measures, water harvesting practices,the minimisation of evaporation losses, the development of the ground water potential and the transfer of surface water from surplus areas where feasible and appropriate. Pastures, forestry or other modes of development which are relatively less water-demanding should be encouraged. In planning water resource development projects, the needs of drought-prone areas should be given priority.

18.2 Relief works undertaken for providing employment to drought-stricken populations should preferably be for drought proofing.

Science and Technology

19. For effective and economical management of our water resources, the frontiers of knowledge need to be pushed forward in several directions by intensifying research efforts in various areas, including the following :

- hydrometeorology;
- assessment of water resources;
- snow and lake hydrology;
- ground water hydrology and recharge;
- prevention of salinity ingress;
- water-harvesting;
- evaporation and seepage losses;
- economical designs for water resources projects;
- crops and cropping systems;
- sedimentation of reservoirs;
- the safety and longevity of water-related structures;
- river morphology and hydraulics;
- better water management practices and improvements in operational technology;
- recycling and re-use;
- use of sea water resources.

Training

20. A perspective plan for standardised training should be an integral part of water resource development. It should cover training in information systems, sectoral planning, project planning and formulation, project management, operation of projects and their physical structures and systems and the management of the water distribution systems. The training should extend to all the categories of personnel involved in these activities as also the farmers.

Conclusion

21. In view of the vital importance of water for human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds, and considering its increasing scarcity, the planning and management of this resource and its optimal, economical and equitable use has become a matter of the utmost urgency. The success of the national water policy will depend entirely on the development and maintenance of a national consensus and commitments to its underlying principles and objectives.

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
NEW DELHI
SEPTEMBER, 1987

Basin Area - Statewise

Annexure - 3.1

S.No.	State/UT	Geographical Area Km^2	Basin Areas in Km^2														
			Indus	Ganga	Brahmaputra	Meghna	Subernarekha	Brahmani-Baitarani	Mahanadi	Godavari	Krishna	Pennar	Cauvery	Tapi	Narmada	Mahi	Sabarmati
			1	2a	2b	2c	3	4	5	6	7	8	9	10	11	12	13
1	Andhra Pradesh	275050								73201	76252	48276					
2	Arunachal Pradesh	83740			83740												
3	Assam	78440			71216	7224											
4	Bihar	173880		143803			13685	15757	635								
5	Goa	3700															
6	Gujarat	196020												3837	11399	11694	17550
7	Haryana	44210	9939	34271													
8	Himachal Pradesh	55670	51358	4312													
9	Jammu & Kashmir	222240	193762														
10	Karnataka	191790								4405	113271	6937	36240				
11	Kerala	38860											2930				
12	Madhya Pradesh	443450		199385				1316	75136	65255				9804	85859	6695	
13	Maharashtra	307710							238	152199	69425			51504	1538		
14	Manipur	22330				9550											
15	Meghalaya	22430			11780	10650											
16	Mizoram	21080				8280											
17	Nagaland	16580			10895	728											
18	Orissa	155710					11964	34749	65580	17752							
19	Punjab	50360	50306														
20	Rajasthan	342240	15814	112490												16453	4124
21	Sikkim	7100			7100												
22	Tamil Nadu	130060											48581				
23	Tripura	10490				4725											
24	Uttar Pradesh	294410		294410													
25	West Bangal	88750		72618	12585		3547										
26	UTs	10960	110	1480									149				
	Total	**3287260**	**321289**	**862769**	**197316**	**41157**	**29196**	**51822**	**141589**	**312812**	**258948**	**55213**	**87900**	**65145**	**98796**	**34842**	**21674**

Basin Area - Statewise

Annexure-3.1

S.No.	State/UT	WFRivers of Kachchh, Saurashtra and Luni	WF Rivers South of Tapi	EFRivers Mahanadi to Godavari	EFRivers Godavari to Krishna	EFRivers Krishna to Pennar	EFRivers Pennar to Cauvery	EFRivers South of Cauveri	Area of North Ladakh not draining into Indus	Rivers draining into Bangla-desh	Rivers draining into Myanmar	Drainage areas of Andman, Nicobar & Laksha-dweep Islands	Total
		14	15	16	17	18	19	20	21	22	23	24	
1	Andhra Pradesh			23905	12289	24649	16478						275050
2	Arunachal Pradesh												83740
3	Assam												78440
4	Bihar												173880
5	Goa		3700										3700
6	Gujarat	140932	10608										196020
7	Haryana												44210
8	Himachal Pradesh												55670
9	Jammu & Kashmir								28478				222240
10	Karnataka		24764				6173						191790
11	Kerala		35930										38860
12	Madhya Pradesh												443450
13	Maharashtra		32806										307710
14	Manipur										12780		22330
15	Meghalaya												22430
16	Mizoram									4266	8534		21080
17	Nagaland										4957		16580
18	Orissa			25665									155710
19	Punjab	54											50360
20	Rajasthan	193359											342240
21	Sikkim												7100
22	Tamil Nadu		4694				41769	35026					130060
23	Tripura									5765			10490
24	Uttar Pradesh												294410
25	West Bangal												88750
26	UTs	45	565				331					8280	10960
	Total	**334390**	**113067**	**49570**	**12289**	**24649**	**64751**	**35026**	**28478**	**10031**	**26271**	**8280**	**3287260**

Summary of Projected Water Use for Diverse Purposes - Basinwise

S.No.	Basins	Catchment Area	Population	Sur.Water Potential (Av.Annual)	Utilisable Surface Water	Total Replenishable Ground Water Resource (Average Annual)	Natural ground water recharge from rainfall	Estimated Utilisable Flow excluding Ground Water	Net Cropped Area (NCA)		Gross Cropped Area (GCA)			Gross Irrigated Area (GIA)		
									NCA 93-94	NCA 2050	GCA 93-94	GCA 2050 Low	GCA 2050 High	GIA 93-94	GIA 2050 Low	GIA 2050 High
		km^2	million	km^3/ Year	km^3/ Year	km^3/ Year	km^3/ Year	km^3/ Year	mha	mha	mha	mha	mha	mha	mha	mha
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Indus	321289	41.9	73	46	26.5	14.29	46	9.59	9.790	15.681	16.636	17.615	9.274	10.315	10.851
2	Ganga-Brahmaputra-Meghna															
2.(a)	Ganga	862769	356.8	525	250	171	135.9	250	46.050	46.990	61.310	68.608	73.307	33.037	49.123	67.442
2.(b)	Brahmaputra	197316	29.1	629	24	26.55	25.72	21	6.140	6.270	6.849	8.270	8.897	0.990	3.722	5.160
2.(c)	Meghna	41157	6.2	48		8.52	8.52	3	1.110	1.130	1.240	1.495	1.608	0.139	0.718	1.367
3	Subernarekha	29196	9.5	12	6.81	1.8	1.68	6.81	1.190	1.210	1.863	2.125	2.247	0.624	0.956	1.123
4	Brahmani-Baitarani	51822	9.8	28	18.3	4.05	3.35	18.3	1.940	1.980	3.132	3.464	3.662	0.958	2.079	3.003
5	Mahanadi	141589	26.6	67	49.99	16.5	13.64	49.99	5.980	6.100	8.364	10.252	10.882	2.012	5.844	7.617
6	Godavari	312812	54	111	76.3	40.6	33.48	76.3	14.390	14.680	18.993	22.026	23.454	4.117	11.013	14.072
7	Krishna	258948	60.8	70	58	26.4	19.88	58	13.190	13.460	15.679	23.689	25.080	3.882	9.476	11.286
8	Pennar	55213	9.7	6	6.86	4.93	4.04	6.86	2.330	2.380	2.677	3.400	3.642	0.989	1.258	1.351
9	Cauvery	87900	29.3	21	19	12.3	8.79	19	4.070	4.150	5.255	6.354	6.790	1.918	2.351	2.716
10	Tapi	65145	14.8	15	14.5	8.27	6.67	14.5	3.750	3.830	4.830	5.740	6.123	0.729	1.435	1.837
11	Narmada	98796	14.7	46	34.5	10.8	9.38	34.5	4.680	4.780	5.535	6.590	7.068	1.266	2.636	3.110
12	Mahi	34842	10.5	11	3.1	4	3.5	3.1	1.880	1.920	2.300	2.724	2.916	0.537	0.953	1.108
13	Sabarmati	21674	10.6	4	1.93	3.2	2.9	1.93	1.560	1.590	1.850	2.213	2.372	0.344	0.620	0.830
14	West Flowing Rivers of Kachchh & Saurashtra including Luni	334390	29.2	15	14.98	11.2	9.1	14.98	11.695	11.930	13.449	14.321	14.834	2.017	2.148	2.225
15	West Flowing Rivers south of Tapi	113057	58.4	201	36.21	17.7	15.55	36.21	4.680	4.780	7.358	8.357	8.835	1.448	2.925	4.418
16/17/18	East Flowing Rivers between Mahanadi and Pennar	86508	23.6	23	13.11	18.8	12.82	13.11	3.510	3.580	4.413	5.229	5.588	1.524	2.562	3.464
19/20	East Flowing Rivers south of Pennar	99777	45	16	16.73	18.2	12.65	16.73	4.160	4.250	5.392	6.368	6.792	2.492	2.802	2.853
21/22	Rivers draining into Bangladesh & Myanmar	36302	2.1	31	Not Assessed				0.200	0.200	0.250	0.294	0.314	0.070	0.118	0.173
23	Area of North Ladakh not draining into Indus	28478	Not Assessed													
24	Drainage areas of Andaman, Nicobar and Lakshadweep Islands	8280	Not Assessed													
	Total	3287260	842.60	1952	690.32	431.32	341.86	690.32	142.095	145.00	186.42	218.16	232.03	68.367	113.054	146.006

Summary of Projecated Water Use for Diverse Purposes-Basinwise

Basins	Gross Irrigated Area - surface water (GIA)				Gross Irrigated Area - Ground water (GIA)			Proposed Total Water Use for Irrigaton		Proposed Return Flow From Irrigation		Proposed Net Water Use For Irrigation		Proposed Total Water Use for All Uses		Proposed Return Flow From All Uses		Proposed Net Water Use For All Uses	
	GIA 93-94	GIA 93-94	GIA 2050 Low	GIA 2050 High	GIA 93-94	GIA 2050 Low	GIA 2050 High	Year 2050 Low	Year 2050 High	Year 2050 Low	Year 2050 High	Year 2050 Low	Year 2050 High	Year 2050 Low	Year 2050 High	Year 2050 Low	Year 2050 High	Year 2050 Low	Year 2050 High
	%	mha	mha	mha	mha	mha	mha	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3
2	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Indus	44	4.08056	5.054	5.588	5.193	5.261	5.263	54	57.1	29.3	32.4	24.7	24.7	72.45	77.12	16	17.2	56.5	59.9
Ganga-Brahmaputra-Meghna																			
Ganga	40	13.2148	26.625	34.8	19.822	22.498	32.642	257.9	353.5	155.8	204.3	102.1	149.2	387.22	494.08	85.7	108.9	301.5	385.2
Brahmaputra	87	0.8613	1.303	1.032	0.129	2.419	4.128	23.5	31.5	9.5	7.5	14.0	24.0	46.83	55.83	7.9	9.2	38.9	46.6
Meghna	98	0.13622	0.179	0.246	0.003	0.539	1.121	5.3	10	1.6	2.2	3.7	7.8	7.44	12.33	1.7	2.5	5.7	9.8
Subernarekha	55	0.3432	0.622	0.753	0.281	0.334	0.370	5.1	6	3.5	4.3	1.6	1.7	8.83	10.05	2	2.3	6.8	7.8
Brahmani-Baitarani	56	0.53648	1.497	2.403	0.422	0.582	0.600	10.2	15	7.8	12.5	2.4	2.5	15.99	21.12	3.3	4.6	12.7	16.5
Mahanadi	55	1.1066	3.214	3.626	0.905	2.630	3.991	35.7	45.8	21.5	24.3	14.2	21.5	49.93	60.96	18.5	23.1	31.4	37.9
Godavari	49	2.01733	5.396	6.009	2.100	5.617	8.063	55.5	69.9	30.2	33.6	25.3	36.3	82.44	98.78	26.2	31.9	56.2	66.9
Krishna	59	2.29038	5.875	6.207	1.592	3.601	5.079	52.5	61.6	35.2	37.2	17.3	24.4	80.39	91.53	23.6	27.1	56.8	64.4
Pennar	62	0.61318	0.805	0.878	0.376	0.453	0.473	8.8	9.4	6	6.6	2.8	2.8	12.84	13.84	4.2	4.5	8.6	9.3
Cauvery	56	1.07408	1.114	1.119	0.844	1.237	1.597	20.2	23	10.7	10.7	9.5	12.3	31.42	35.19	9.6	10.8	21.8	24.4
Tapi	36	0.26244	0.832	1.194	0.467	0.603	0.643	8.5	11.1	5.4	7.8	3.1	3.3	15.13	18.19	3.3	4.1	11.8	14.1
Narmada	47	0.59502	1.766	2.115	0.671	0.870	0.995	16	18.9	11.5	13.7	4.5	5.2	27.26	30.71	5.2	6	22.1	24.7
Mahi	34	0.18258	0.543	0.687	0.354	0.410	0.421	5.1	6	3.2	4.1	1.9	1.9	8.94	10.19	2.1	2.4	6.8	7.8
Sabarmati	25	0.086	0.30	0.465	0.258	0.316	0.365	3.7	5	2	3.1	1.7	1.9	7.01	8.66	1.7	2.1	5.3	6.6
West Flowing Rivers of Kachchh & Saurashtra including Luni	31	0.62527	0.709	0.779	1.392	1.439	1.446	12.4	13	5	5.5	7.4	7.5	27	28.73	6.6	7.1	20.4	21.6
West Flowing Rivers south of Tapi	55	0.7964	2.077	3.534	0.652	0.848	0.884	19.9	30.6	15	25.4	4.9	5.2	38.57	51.08	9.6	12.8	29.0	38.3
East Flowing Rivers betwee-n Mahanadi and Pennar	61	0.92964	1.742	2.598	0.594	0.820	0.866	14.1	19.4	10.3	15.3	3.8	4.1	21.36	27.41	5.4	6.9	16.0	20.5
East Flowing Rivers south of Pennar	53	1.32076	1.681	1.569	1.171	1.121	1.284	17.8	17.9	11.6	10.8	6.2	7.1	28.9	30.44	7.8	8.3	21.1	22.1
Rivers draining into Bangladesh & Myanmar		0.04	0.06	0.104	0.030	0.059	0.069	1.6	2.4	0.9	1.6	0.7	0.8	2.85	3.75	0.7	0.9	2.2	2.9
Area of North Ladakh not draining into Indus					0.000	0.000	0.000					0.0	0.0				0	0.0	0.0
Drainage areas of Andaman, Nicobar and Lakshadweep Islands					0.000	0.000	0.000					0.0	0.0				0	0.0	0.0
Total	45	31.125	61.394	75.706	37.256	51.657	70.300	628	807	376	463	252.0	344.0	973	1180	241	293	732.0	887.0

Annexure - 3.3

Summary of Projected Water Use for Diverse Purposes - State-wise

S.No.	State/UT	Geographical area-	Reporting area	Total cultivable land	Ultimate Irrig. Potential			Net Cropped Area (NCA)				Gross Cropped Area (GCA)							Average Annual Rainfall
					Surface water	Ground water	Total	NCA 93-94	NCA 2010	NCA 2025	NCA 2050	GCA 93-94	GCA 2010 Low	GCA 2010 High	GCA 2025 Low	GCA 2025 High	GCA 2050 Low	GCA 2050 High	
		1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	mm
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Andhra Pradesh	27505	27440	15855	7300	3960	11260	10362	10428	10501	10574	12688	13035	13035	13651	13809	14486	15861	576-1054
2	Arunachal Pradesh	8374	5544	268	150	18	168	150	151	152	153	258	260	260	269	272	274	276	2359
3	Assam	7844	NA	3229	1970	900	2870	2706	2723	2742	2761	3817	3949	3949	4113	4168	4195	4418	1840-3528
4	Bihar	17388	17082	11084	8400	4947	13347	7267	7313	7364	7416	9748	10604	10604	11047	11157	11198	13720	1103-1404
5	Goa	370	NA	198	25	29	54	138	139	140	141	162	187	187	196	199	211	225	
6	Gujarat	19602	18877	12358	3347	2756	6103	9391	9451	9517	9583	10672	11624	11624	12182	12324	12745	12841	340-844
7	Haryana	4421	4382	3769	3050	1462	4512	3513	3535	3560	3585	5815	5833	5833	6052	6123	6130	6135	320-561
8	Himachal Pradesh	5567	3348	807	285	68	353	572	576	580	584	975	979	979	1014	1026	1028	1030	800-1300
9	Jammu & Kashmir	22224	NA	1049	650	708	1358	736	741	746	751	1080	1081	1081	1126	1141	1141	1425	
10	Karnataka	19179	19040	13049	3400	2574	5974	10790	10859	10935	11011	12432	13030	13030	13668	13832	15965	17617	684-3300
11	Kerala	3886	3885	2444	1800	879	2679	2238	2252	2268	2284	3042	3266	3266	3402	3447	3471	3654	2392-3000
12	Madhya Pradesh	44345	33596	22811	8200	9732	17932	19740	19866	20005	20144	24829	25825	25825	27006	27306	30215	32230	670-1436
13	Maharashtra	30771	30752	21165	5300	3652	8952	18021	18136	18263	18389	21361	21582	21582	22646	22920	26352	27584	602-3640
14	Manipur	2233	2211	164	235	359	594	140	141	142	143	199	204	204	213	216	218	257	
15	Meghalaya	2243	2239	1077	105	63	168	201	202	204	205	239	273	273	285	289	308	328	5109
16	Mizoram	2108	2102	584	70	0	70	65	65	66	66	107	108	108	112	113	113	113	2025
17	Nagaland	1658	1532	648	85	0	85	189	190	192	193	217	257	257	268	272	289	309	2534
18	Orissa	15571	15617	8086	4600	4203	8803	6303	6343	6388	6432	9747	9768	9768	10156	10252	10420	10420	1128-1436
19	Punjab	5036	5037	4254	3050	2917	5967	4214	4241	4270	4300	7623	7634	7634	7900	7964	7970	7975	375-650
20	Rajasthan	34224	33600	25711	3350	1778	5128	16232	16335	16450	16564	19254	19929	19929	20891	21138	23686	23686	360-550
21	Sikkim	710	710	114	70	0	70	95	96	96	97	127	134	134	140	142	145	155	2010
22	Tamil Nadu	13006	12432	8361	2700	2832	5532	5901	5939	5980	6022	7158	7245	7245	7595	7684	8912	9635	780-1113
23	Tripura	1049	1049	310	200	81	281	277	279	281	283	460	463	463	480	486	490	495	2194
24	Uttar Pradesh	29441	29837	20838	13700	16799	30499	17250	17360	17481	17603	25545	26908	26908	28320	28582	28838	32090	721-1214
25	West Bangal	8875	8474	5932	3610	3318	6928	5459	5494	5532	5571	8680	8735	8735	9073	9156	9192	9304	1302-2641
26	UTs	1096	NA	211	201	5	206	145	146	147	148	185	197	197	206	209	222	237	
27	Total	**328726**	**278786**	**184376**	**75853**	**64040**	**139893**	**142095**	**143001**	**144002**	**145003**	**186420**	**193110**	**193110**	**202011**	**204227**	**218214**	**232020**	

Summary of Projected Water Use for Diverse Purposes - Statewise

State/UT	Gross Irrigated Area (GIA)							GIA Ultimate - GIA 2050	Water Required for Irrigation-Total						Water Required for Irrigation-Surface Water					
	GIA 93-94	GIA 2010 Low	GIA 2010 High	GIA 2025 Low	GIA 2025 High	GIA 2050 Low	GIA 2050 High		Year 2010 Low	Year 2010 High	Year 2025 Low	Year 2025 High	Year 2050 Low	Year 2050 High	Year 2010 Low	Year 2010 High	Year 2025 Low	Year 2025 High	Year 2050 Low	Year 2050 High
	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	1000 ha	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3
1	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Andhra Pradesh	5020	5475	5605	6416	7181	8433	11103	157	50.9	52.6	50.3	56.8	60.2	77.6	37.2	38	33.8	39.8	42.2	54
Arunachal Pradesh	36	52	55	67	76	158	193	-25	0.6	0.6	0.6	0.7	1.2	1.4	0.6	0.6	0.6	0.7	1.1	1.1
Assam	572	869	908	1111	1250	2278	3093	-223	15.7	16.3	17.6	19.8	31.2	43	12.6	13	13.2	14.6	24.5	29.2
Bihar	4212	5302	5408	6407	6940	8342	12760	587	37.2	37.9	43.8	47.4	52.3	79.1	21.6	22.1	26.2	27.8	32.4	54.9
Goa	35	51	52	63	64	66	67	-13	0.3	0.3	0.4	0.4	0.4	0.4	0.1	0.1	0.2	0.2	0.2	0.2
Gujarat	3087	3836	3952	4629	4954	5350	6300	-197	25.4	26.2	30	32.6	31.9	37.7	11.5	12	14	16.5	15.3	21.4
Haryana	4515	4550	4608	5023	5082	5116	5150	-638	29.3	29.7	27.9	28.2	25.5	25.4	19	19	18	18	15.4	16.2
Himachal Pradesh	171	235	245	294	328	339	353	0	1.5	1.6	1.5	1.7	1.5	1.5	1	1	1	1	1.3	1.3
Jammu & Kashmir	444	519	530	597	639	733	1358	0	4.5	4.6	4.1	4.4	4.2	7.2	4	5	4	4	3.6	3.8
Karnataka	2971	3388	3518	4237	4703	4790	7047	-1073	25.0	25.9	25.2	28	25.2	36.2	20	20	18	20	17	19
Kerala	413	686	718	885	1000	2056	2667	12	7.4	7.7	7.9	8.9	15	19.7	6.8	7	6.7	7.6	12.8	14
Madhya Pradesh	5529	6456	6715	8102	9011	11482	18960	-1028	35.6	37	38.4	43.1	49.2	77.8	22.4	23.3	23.4	27.3	31.5	36.9
Maharashtra	3262	4316	4532	5661	6417	6852	8952	0	39.6	41.6	45.3	51.3	50.5	65.8	22.8	24	25	29.3	28.8	41.3
Manipur	75	92	94	106	114	193	594	0	1.1	1.1	1	1	1.4	4	1.1	1.1	1	1	1.1	1.8
Meghalaya	45	55	57	71	81	139	168	0	0.6	0.6	0.6	0.7	1	1.2	0.6	0.6	0.6	0.7	0.7	0.8
Mizoram	8	16	17	22	26	68	70	0	0.2	0.2	0.2	0.2	0.5	0.5	0.2	0.2	0.2	0.2	0.5	0.5
Nagaland	63	82	85	99	101	107	110	-25	0.9	1	0.9	0.9	0.8	0.8	0.9	1	0.9	0.9	0.8	0.8
Orissa	2510	3028	3126	3656	4890	6947	8803	0	16.1	16.6	16.4	22.5	26.9	33.6	11.5	11.8	11.0	16.7	16.8	18.9
Punjab	7238	7290	7313	7616	7678	7706	7720	-1753	48.8	49	44.9	44.9	41.2	41	25.2	25.3	21.1	21.3	17.8	17.5
Rajasthan	5595	6078	6377	6476	6595	6751	6800	-1672	43.6	46.5	40.8	41.3	38.3	39.1	23.2	25.1	19.7	20.1	17.6	20.8
Sikkim	16	27	28	35	40	57	70	0	0.3	0.3	0.3	0.4	0.4	0.5	0.3	0.3	0.3	0.4	0.4	0.5
Tamil Nadu	3544	3840	3915	4405	4688	4723	5723	-191	36.1	36.7	37.4	39.9	35.3	43	22.4	22.7	22.4	24.1	20.3	21.9
Tripura	60	120	125	149	165	250	281	0	1.2	1.2	1.2	1.4	1.7	1.9	1.1	1.1	1.1	1.1	1.3	1.5
Uttar Pradesh	16364	17759	17947	21013	22122	24845	30499	0	95.4	97.1	99	106.9	102	124.5	46.6	47.1	45.9	53.9	51.9	61.7
West Bangal	2491	2970	3057	3538	3937	5158	7164	-236	22.7	23.5	23.7	26.4	29.3	41	16.4	16.7	15.9	17.4	19.2	22.5
UTs	91	112	114	128	136	182	206	0	0.8	0.8	0.8	0.8	1	1.2	0.4	0.4	0.4	0.5	0.7	1.2
Total	**68367**	**77204**	**79101**	**90806**	**98218**	**113121**	**146211**	**-6318**	**541**	**557**	**560**	**611**	**628**	**805**	**330**	**339**	**325**	**366**	**375**	**464**

Summary of Projected Water Use for Diverse Purposes-Statewise

State/UT	Water Required for Irrigation-Ground Water						Total Water Required for all Uses					
	Year 2010 Low	Year 2010 High	Year 2025 Low	Year 2025 High	Year 2050 Low	Year 2050 High	Year 2010 Low	Year 2010 High	Year 2025 Low	Year 2025 High	Year 2050 Low	Year 2050 High
	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3
1	41	42	43	44	45	46	47	48	49	50	51	52
Andhra Pradesh	13.7	14.6	16.5	17.0	18.0	23.6	64.7	66.4	71.1	78.5	90.2	109.8
Arunachal Pradesh	0.0	0.0	0.0	0.0	0.1	0.3	1.4	1.4	2	2.1	12.3	12.6
Assam	3.1	3.3	4.4	5.2	6.7	13.8	18.2	18.8	21.8	24.1	37.6	50.1
Bihar	15.6	15.8	17.6	19.6	19.9	24.2	47	47.7	59.7	64.3	77.2	106.6
Goa	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.7	0.8	0.8	0.9
Gujarat	13.9	14.2	16.0	16.1	16.6	16.3	34.5	35.3	42.9	46	49.6	56.8
Haryana	10.3	10.7	9.9	10.2	10.1	9.2	31.7	32.1	31.3	31.8	31.2	31.6
Himachal Pradesh	0.5	0.6	0.5	0.7	0.2	0.2	5.7	5.8	5.7	6	6.5	6.7
Jammu & Kashmir	0.5	-0.4	0.1	0.4	0.6	3.4	7	7.1	8.7	9.1	12	15.5
Karnataka	5.0	5.9	7.2	8.0	8.2	17.2	35.5	36.4	39.5	42.7	46.3	58.8
Kerala	0.6	0.7	1.2	1.3	2.2	5.7	11.3	11.6	14.3	15.6	25.3	30.9
Madhya Pradesh	13.2	13.7	15.0	15.8	17.7	40.9	49.7	51.2	62.2	67.6	82.6	113.6
Maharashtra	16.8	17.6	20.3	22.0	21.7	24.5	54.1	56.1	67.1	74.0	83.7	101.5
Manipur	0.0	0.0	0.0	0.0	0.3	2.2	1.5	1.5	1.6	1.7	2.4	5.1
Meghalaya	0.0	0.0	0.0	0.0	0.3	0.4	1.1	1.2	1.3	1.5	2	2.2
Mizoram	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.6	0.6	1.1	1.2
Nagaland	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.5	1.6	6	6.1
Orissa	4.6	4.8	5.4	5.8	10.1	14.7	23.5	24	26.3	32.8	41.4	49.1
Punjab	23.6	23.7	23.8	23.6	23.4	23.5	51	51.1	48.6	48.8	47.1	47.5
Rajasthan	20.4	21.4	21.1	21.2	20.7	18.3	52.4	55.3	53.7	54.8	57.2	59.6
Sikkim	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.5	0.5	0.7	0.8
Tamil Nadu	13.7	14.0	15.0	15.8	15.0	21.1	43.5	44.1	48.5	51.6	52.2	61.7
Tripura	0.1	0.1	0.1	0.3	0.4	0.4	1.6	1.6	1.8	2	6.6	6.9
Uttar Pradesh	48.8	50.0	53.1	53.0	50.1	62.8	116.4	118	127.5	137	144.8	171.6
West Bangal	6.3	6.8	7.8	9.0	10.1	18.5	36.5	37.3	41.1	44.5	52.6	66.4
UTs	0.4	0.4	0.4	0.3	0.3	0.0	1.8	1.8	2.3	2.5	3.5	4
Total	**211**	**218**	**236**	**246**	**253**	**341**	**694**	**708**	**783**	**843**	**973**	**1178**

State/UT	Total Return Flow						Net Water Requirement					
	Year 2010 Low	Year 2010 High	Year 2025 Low	Year 2025 High	Year 2050 Low	Year 2050 High	Year 2010 Low	Year 2010 High	Year 2025 Low	Year 2025 High	Year 2050 Low	Year 2050 High
	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3	km^3
1	53	54	55	56	57	58	59	60	61	62	63	64
Andhra Pradesh	19	19.5	17.8	20	19.6	24.2	45.7	46.9	53.3	58.5	70.6	85.6
Arunachal Pradesh	0.5	0.5	0.7	0.7	0.9	0.9	0.9	0.9	1.3	1.4	11.4	11.7
Assam	6.1	6.3	6.3	6.9	9.1	11.6	12.1	12.5	15.5	17.2	28.5	38.5
Bihar	14.2	14.4	16.2	17.4	18.5	25.6	32.8	33.3	43.5	46.9	58.7	81.0
Goa	0.1	0.1	0.2	0.2	0.2	0.2	0.4	0.4	0.5	0.6	0.6	0.7
Gujarat	8.7	8.9	10.1	11	10.6	12.5	25.8	26.4	32.8	35.0	39.0	44.3
Haryana	9.4	9.5	8.1	8.3	6.8	7	22.3	22.6	23.2	23.5	24.4	24.6
Himachal Pradesh	0.9	0.9	1	1.1	1.1	1.2	4.8	4.9	4.7	4.9	5.4	5.5
Jammu & Kashmir	2.5	2.6	2.8	2.9	2.9	3.5	4.5	4.5	5.9	6.2	9.1	12.0
Karnataka	10.2	10.4	9.9	10.8	10	12.4	25.3	26.0	29.6	31.9	36.3	46.4
Kerala	3.7	3.8	3.9	4.3	5.9	7.1	7.6	7.8	10.4	11.3	19.4	23.8
Madhya Pradesh	14.1	14.5	15.3	16.9	18	23.7	35.6	36.7	46.9	50.7	64.6	89.9
Maharashtra	15	15.5	16.6	18.6	18.2	22.6	39.1	40.6	50.5	55.4	65.5	78.9
Manipur	0.5	0.5	0.5	0.5	0.6	1.1	1.0	1.0	1.1	1.2	1.8	4.0
Meghalaya	0.4	0.4	0.4	0.4	0.5	0.5	0.7	0.8	0.9	1.1	1.5	1.7
Mizoram	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.4	0.4	0.8	0.9
Nagaland	0.4	0.4	0.4	0.4	0.4	0.4	0.8	0.8	1.1	1.2	5.6	5.7
Orissa	6.6	6.7	6.7	8.6	8.9	10.5	16.9	17.3	19.6	24.2	32.5	38.6
Punjab	14.2	14.2	11.7	11.8	9.7	9.9	36.8	36.9	36.9	37.0	37.4	37.6
Rajasthan	14.6	15.4	13.5	13.9	12.8	13.8	37.8	39.9	40.2	40.9	44.4	45.8
Sikkim	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.5	0.6
Tamil Nadu	12.9	13.1	12.8	13.7	12.2	14.2	30.6	31.0	35.7	37.9	40.0	47.5
Tripura	0.5	0.5	0.5	0.6	0.7	0.7	1.1	1.1	1.3	1.4	5.9	6.2
Uttar Pradesh	31.5	31.8	31.5	34.5	32.5	38.5	84.9	86.2	96.0	102.5	112.3	133.1
West Bangal	9.8	9.9	10.1	11	11.9	14.8	26.7	27.4	31.0	33.5	40.7	51.6
UTs	0.7	0.7	0.8	0.9	1.2	1.4	1.1	1.1	1.5	1.6	2.3	2.6
Total	**197**	**201**	**198**	**216**	**214**	**259**	**496**	**508**	**584**	**627**	**759**	**919**

Annexure-4.1

Statewise Break-up of Geographical Area, Areas prone to Floods, Maximum Area Affected and Area Benefitted

(Area in Million ha)

S. No.	Name of State/UT	Geographical area	Area liable to floods	Maximum area affected any one year during 1953-93 (with year)	Area benefitted upto March, 1993
1	2	3	4	5	6
1.	Andhra Pradesh	27.505	1.39	3.480 (1989)	1.0123
2.	Arunachal Pradesh	8.374	-	0.030 (1088)	-
3.	Assam	7.844	3.15	3.820 (1988)	1.7269
4.	Bihar	17.388	4.26	4.260 (1971)	1.8890
5.	Goa	0.370	-	Neg. (1976)	0.0001
6.	Gujarat	19.602	1.39	2.050 (1988)	0.4410
7.	Haryana	4.421	2.35	1.000 (1977)	1.7300
8.	Himachal Pradesh	5.567	0.23	0.410 (1989)	0.0120
9.	Jammu & Kashmir	22.224	0.08	0.514 (1987)	0.1834
10.	Karnataka	19.179	0.02	0.900 (1988)	0.0570
11.	Kerala	3.886	0.87	1.470 (1989)	0.0518
12.	Madhya Pradesh	44.345	0.26	0.260 (1953)	0.0040
13.	Maharashtra	30.771	0.23	0.330 (1989)	0.0010
14.	Manipur	2.233	0.08	0.80 (1989)	0.0900
15.	Meghalaya	2.243	0.02	0.095 (1987)	0.0896
16.	Mizoram	2.108	-	Neg. (1990)	-
17.	Nagaland	1.658	-	0.008 (1985)	-
18.	Orissa	15.571	1.40	1.400 (1960)	0.4800
19.	Punjab	5.036	3.70	2.790 (1988)	2.6750
20.	Rajasthan	34.224	3.26	3.260 (1977)	0.0816
21.	Sikkim	0.710	-	0.020 (1984)	0.0002
22.	Tamil Nadu	13.006	0.45	0.450 (1961)	0.1220
23.	Tripura	1.049	0.33	0.330 (1963)	0.0308
24.	Uttar Pradesh	29.441	7.34	7.340 (1978)	1.5320
25.	West Bengal	8.875	2.65	3.080 (1978)	2.0770
26.	A& N Island	0.825	-	0.030 (1988)	-
27.	Chandigarh	0.011	-	(1993)	-
28.	Dadra & Nagar Haveli	0.049	-	Neg. (1976)	-
29.	Daman & Diu	0.011	-	Nil (1993)	-
30.	Delhi	0.148	0.05	0.070 (1978)	0.0780
31.	Lakshadweep	0.003	-	Neg. (1978)	-
32.	Pondicherry	0.049	0.01	0.050 (1977)	0.0093
	Total	**328.726**	**33.52** **Say 34.00**	@ **17.500**	**14.3740**

Note

Neg.: *Neglibible*

Total Area liable to floods is 40 million hectares. (80% of this i.e. 32 M.has is protectable *including areas protectable as assessed by RBA)*

@ Total of the maximum area affected in one year in the country.

Source : Flood Management Programme, Directorate , CWC.

Annexure-4.2

Progress of Physical Works Under Flood Management Programme Completed up to 1993

S. No.	Name of State/ UT	Length of embankment (km)	Length of drainage channels (km)	Towns/ villages protection works (Nos)	Villages raised/ protected (Nos)
1	2	3	4	5	6
1.	Andhra Pradesh	572	13569	52	21
2.	Arunachal Pradesh	2	-	-	-
3.	Assam	4566	957	89	16
4.	Bihar	2788	365	47	-
5.	Goa	10	12	4	6
6.	Gujarat	952	271	229	30
7.	Haryana	662	3922	180	90
8.	Himachal Pradesh	58	11	-	-
9.	Jammu & Kashmir	80	14	12	5
10.	Karnataka	-	-	-	-
11.	Kerala	113	28	4	6
12.	Madhya Pradesh	21	-	37	-
13.	Maharashtra	26	-	26	-
14.	Manipur	300	76	1	1
15.	Meghalaya	112	-	8	2
16.	Mizoram	1	1	-	-
17.	Nagaland	-	-	-	-
18.	Orissa	1068	131	14	29
19.	Punjab	1370	6622	3	-
20.	Rajasthan	145	197	25	-
21.	Sikkim	-	-	6	-
22.	Tamil Nadu	87	19	46	4
23.	Tripura	128	94	11	-
24.	Uttar Pradesh	1811	3593	64	4511
25.	West Bengal	1184	1648	48	-
26.	A&N Island	-	-	-	-
27.	Chandigarh	-	-	-	-
28.	Dadra & Nagar Haveli	-	-	-	-
29.	Daman & Diu	-	-	-	-
30.	Delhi	83	453	-	-
31.	Lakshadweep	-	-	-	-
32.	Pondicherry	61	20	-	-
	Total	**16199**	**32003**	**906**	**4721**

Source : Flood Management Programme, Directorate , CWC.

Annexure-4.3

Statement Showing Flood Damage During 1953-1998

S. No.	Year	Area Affec-ted	Popula-tion affec-ted	Damage to crops		Damages to Houses		Cattle Lost	Huma n Lives Lost	Damage to public utilities	Damage to crops, houses, public utilities (6+8+11)
				Area	Value						
		(Mha)	Million	(Mha)	(Rs. crores)	(Nos.)	(Value in Rs.crores)	(Nos.)	(Nos.)	(Rs. Crores)	(Rs. Crores)
1.	1953	2. 290	24. 280	0. 930	42. 080	264924	7. 420	47034	37	2. 900	52. 400
2.	1954	7. 490	12.920	2. 610	40. 520	199984	6. 561	22552	279	10. 150	57. 231
3.	1955	9 .440	25. 270	5. 310	77. 800	166678	20. 945	72010	862	3. 920	102. 725
4.	1956	9. 240	14. 570	1. 110	44. 440	725776	8. 047	16108	462	1. 140	53. 627
5.	1957	4. 860	6. 760	0. 450	14. 120	318149	4. 979	7433	352	4. 270	23. 369
6.	1958	6. 260	10. 980	1. 400	38. 280	382251	3. 896	18439	389	1. 790	43. 966
7.	1959	5. 770	14. 520	1. 540	56. 760	648821	9. 418	72691	619	20. 020	86. 198
8.	1960	7. 530	8. 350	2. 270	42. 550	609884	14. 309	13908	510	6. 310	63. 169
9.	1961	6. 560	9. 260	1. 970	24. 040	533465	0. 889	15916	1374	6. 440	31. 369
10.	1962	6 .120	15. 460	3. 390	83. 180	513785	10. 665	37633	3 48	1. 050	94. 885
11.	1963	3. 490	10. 930	2. 050	30. 170	420554	3. 701	4572	432	2. 740	36. 611
12.	1964	4. 900	13. 780	2. 490	56. 870	255558	4. 588	4956	690	5. 149	66. 607
13.	1965	1. 460	3. 610	0. 270	5. 870	112957	0. 195	7286	79	1. 070	7. 135
14.	1966	4. 740	14. 400	2. 160	80. 150	217269	2. 544	90 71	180	5. 736	88. 430
15.	1967	7. 120	20. 460	3. 270	133. 310	567995	14. 264	58 27	355	7. 857	155. 431
16.	1968	7. 150	21. 170	2. 620	144. 610	682704	41. 112	130305	3497	25. 373	211. 095
17.	1969	6. 200	33. 220	2. 910	281. 900	1268660	54. 423	270328	1408	68. 112	404. 435
18.	1970	8. 460	31.830	4. 910	162. 780	1434030	48. 606	19198	1076	76. 441	287. 827
19.	1971	13. 250	59. 740	6. 240	423. 130	2428031	80. 241	12866	994	129. 113	632. 484
20.	1972	4. 100	26. 690	2. 450	98. 560	897301	12. 460	58231	544	47. 174	158. 194
21.	1973	11. 790	64. 080	3. 730	428. 030	869797	52. 482	261016	1349	88. 489	569. 001
22.	1974	6. 700	29. 450	3. 330	411. 640	746709	72. 434	16846	387	84. 942	569. 016
23.	1975	6. 170	31. 360	3. 850	271. 490	803705	34. 097	17345	686	166. 050	471. 637
24.	1976	11. 910	50. 460	6. 040	595. 030	1745501	92. 160	80062	1373	201. 495	888. 685
25.	1977	11. 460	49. 430	6. 840	720. 610	1661625	152. 290	556326	11316	328. 948	1201. 848
26.	1978	17. 500	70. 450	9. 960	911. 090	3507542	167. 574	239174	3396	376. 100	1454. 764
27.	1979	3. 990	19. 520	2. 170	169. 970	1328712	210. 606	618248	3637	233. 627	614. 203
28.	1980	11. 460	54. 120	5. 550	366. 370	2533142	170. 851	59173	1913	303. 283	840. 504
29.	1981	6. 120	32. 490	3. 270	524. 560	912557	159. 630	82248	1376	512. 314	1196 504
30.	1982	8. 870	56. 010	5. 000	589. 400	2397365	383. 869	246750	1573	671. 607	1644. 876
31.	1983	9. 020	61. 030	3. 290	1285. 850	2393 722	332. 34	153095	2378	873. 429	2491. 606
32.	1984	10. 710	54. 550	5. 190	906. 090	1763603	181. 308	141314	1661	818. 164	1905. 562
33.	1985	8. 380	59. 590	4. 650	1425. 370	2449878	583. 855	43008	1804	2050. 043	4059. 268
34.	1986	8. 810	55. 500	4. 580	1231. 580	2049277	534. 410	60450	1200	982. 535	3748. 525

35.	1987	8. 890	48. 340	4. 940	1154. 640	2919380	464. 490	128638	1835	950. 590	2569. 720
36.	1988	16. 290	59. 550	10. 150	2510. 900	2276533	741. 600	150996	4252	1377. 800	4630. 300
37.	1989	8. 060	34. 150	3. 010	956. 740	782340	149. 820	75176	1718	1298. 770	2405. 330
38.	1990	9. 303	40. 259	3. 179	695. 610	1019930	213. 733	134154	1855	455. 266	1708. 920
39.	1991	6. 357	33. 889	2. 698	579. 015	1134410	180. 421	41090	1167	728.893	1488. 329
40.	1992	2.645	19. 256	1. 748	1027.578	687489	306.284	78669	1533	2010. 670	3344. 532
41.	1993*	4. 632	22. 901	3. 129	511.190	470951	124.570	11990	930	48. 088	683.848
42.	1994*	2. 752	21. 040	1. 896	888. 619	601379	165. 205	21698	1511	739. 641	1793. 465
43.	1995*	6. 111	38. 831	3. 359	351. 552	1195114	152.595	70371	2209	67. 710	571. 857
44.	1996*	7. 420	39. 393	3. 365	404. 287	406718	95 601	60215	1306	861. 619	2204. 777
45.	1997*	3.855	26.548	1.838	449.743	399534	145.578	27178	929	971.615	1566. 936
46.	1998*	8.623	50.340	5.379	2266.681	1022854	296.430	98456	2549	2815.022	5378.133
	Total	344.258	1500.72	162.49	23514. 755	52228654	6513. 473	4320050	70353	21443.525	52659.334
	Avg	7. 484	32. 624	3. 532	511.190	1135406	141. 597	93914	1529	466.164	1144. 768
	Max	17.500	70 .450	10. 150	2510. 900	3507542	741. 600	618248	11316	2815. 022	5378.133
	Year	1978	1978	1998	1988	1978	1988	1979	1977	1998	1998

**Tentative Figures*

Annexure-4.4

Investment in Irrigation and Flood Control Sectors

S. No.	Plan	Total Irrigation & FC (Crores)	FC (Crores)	% age
1	First Plan	459.77	13.77	3.00
2	Second Plan	590.30	49.15	8.33
3	Third Plan	1110.29	86.00	7.75
4	Annual Plan	1038.35	43.61	4.21
5	Fourth Plan	2582.84	171.78	6.65
6	Fifth Plan	4274.34	298.61	6.98
7	Annual Plan	3360.07	228.47	6.80
8	Sixth Plan	11872.40	590.07	4.97
9	Seventh Plan	19903.13	941.56	4.73
10	Annual Plan	8215.03	460.64	5.60
11	Eighth Plan	32525.29	1915.75	5.89

Annexure-4.5

Status of Hydroelectric Potential Development (Basinwise)

as on 31-08-98

BASIN	POTENTI-AL ASSESSED AT 60% LF	POTENTI-AL DEVELO-PED AT 60% LF	% DEVEL-OPED	POTEN-TIAL UNDER DEVELOP MENT (MW)	% UNDER DEVE-LOP-MENT (MW)	% DEVEL OPED + UNDER DEVE-LOPM-ENT	CEA CLEARED POT. AT 60% LF (MW)	% CEA CLEA-RED POT	% TOTAL
INDUS	19988.00	2935.85	14.69	1332.83	6.67	21.36	1102.42	5.52	26.87
GANGA	. 10715.00	1850.33	17.27	1147.55	10.71	27.98	543.17	5.07	33.05
CENTRAL INDIAN RIVERS	2740.00	634.33	23.15	1528.00	55.77	78.92	221.95	8.10	87.02
WEST FLOWING RIVERS	6149.00	3445.33	56.03	756.13	12.30	68.33	56.17	0.91	69.24
EAST FLOWING RIVERS	9532.00	3661.42	38.41	701.32	7.36	45.77	37.73	0.40	46.17
BRAHMA-PUTRA BASIN	34920.00	452.67	1.30	366.72	1.05	2.35	818.00	2.34	4.69
ALL INDIA	84044.00	12979.93	15.44	5832.55	6.94	22.38	2779.43	3.31	25.69

Annexure – 4.6

Status of Hydroelectric Potential Development
(Statewise)

as on 31-08-98

Region/State	Potential assessed at 60 % LF (MW)	Potential developed at 60 % LF (MW)	% developed	Potential Under Develop-ment at 60% LF (MW)	% under devel-opment	% of potential dev'ped +under dev'ment	CEA cleared schemes potential at 60% LF (MW)	% CEA cleared schemes	% oftotal Potential dev'ped + UN.Dev'nt +CEA cleared
NORTHERN									
Jammu & Kashmir	7487.00	480.17	6.41	407.17	5.11	11.85	503.17	6.72	18.57
Himachal Pradesh	11647.00	2007.00	17.23	549.17	4.72	21.95	583.25	5.01	26.95
Punjab	922.00	454.67	49.31	375.00	40.67	89.99	39.33	4.27	94.25
Haryana	64.00	51.67	80.73	11.67	18.23	98.96	0.00	0.00	98.96
Rajasthan	291.00	192.67	66.21	8.00	2.75	68.96	0.00	0.00	68.96
Uttar Pradesh	9744.00	1127.00	11.57	1117.67	11.47	23.04	405.67	4.16	27.20
Sub Total (NR)	30155.00	4313.23	14.30	2468.67	8.19	22.49	1531.42	5.08	27.57
WESTERN									
Madhya Pradesh	2774.00	579.50	20.89	1211.05	43.66	64.55	234.45	8.45	73.00
Gujarat	409.00	138.67	33.90	110.67	27.06	60.96	0.00	0.00	60.96
Maharashtra	2460.00	1108.00	45.04	197.67	8.04	53.08	0.00	0.00	53.08
Goa	36.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub Total (WR)	5679.00	1826.17	32.16	1519.38	26.75	58.91	234.45	4.13	63.04
SOUTHERN									
Andhra Pradesh	2909.00	1392.92	47.88	43.70	1.50	49.39	36.23	1.25	50.63
Karnataka	4347.00	2139.50	49.22	490.33	11.28	60.50	4.83	0.11	60.61
Kerala	2301.00	1068.67	46.44	276.13	12.00	58.44	41.50	1.80	60.25
Tamilnadu	1206.00	944.67	78.33	69.33	5.75	84.08	11.33	0.94	85.02

Sub Total (SR)	10763.00	5545.75	51.53	879.50	8.17	59.70	93.90	0.87	60.57
EASTERN									
Bihar	538.00	119.95	22.30	211.00	39.22	61.51	0.00	0.00	61.51
Orissa	1983.00	722.17	36.42	387.28	19.53	55.95	0.00	0.00	55.95
West Bengal	1786.00	91.33	5.11	9.83	0.55	5.66	101.67	5.69	11.36
Sikkim	1283.00	28.83	2.25	33.67	2.62	4.87	355.67	27.72	32.59
Sub Total (ER)	5590.00	962.28	17.21	641.78	11.48	28.70	457.33	8.18	36.88
NORTH EASTERN									
Meghalaya	1070.00	121.67	11.37	0.00	0.00	11.37	0.00	0.00	11.37
Tripura	9.00	8.50	94.44	0.00	0.00	94.44	0.00	0.00	94.44
Manipur	1176.00	73.17	6.22	5.33	0.45	6.68	42.50	3.61	10.29
Assam	351.00	111.67	31.81	90.83	25.88	57.69	0.00	0.00	57.69
Nagaland	1040.00	0.00	0.00	81.88	7.87	7.87	0.00	0.00	7.87
Arunachal Pradesh	26756.00	16.50	0.06	108.33	0.40	0.47	251.67	0.94	1.41
Mizoram	1455.00	1.00	0.07	36.83	2.53	2.60	168.17	11.56	14.16
Sub Total (NER)	31857.00	332.50	1.04	323.22	1.01	2.06	462.33	1.45	3.51
ALL INDIA	**84044.00**	**12979.93**	**15.44**	**5832.55**	**6.94**	**22.38**	**2779.43**	**3.31**	**25.69**

Annexure-4.7

Small Hydro Power Potential of the Country

		No. of Schemes	Installed Capacity (KW)
NORTHERN REGION			
	Jammu & Kashimar	107	825530
	Himachal Pradesh	162	1185870
	Punjab	24	23400
	Haryana	4	9700
	Rajasthan	31	37445
	Uttar Pradesh	217	1097595
	TOTAL (Northern Region)	545	3179540
WESTERN REGION			
	Madhya Pradesh	48	223930
	Gujarat	105	121675
	Maharashtra	53	313130
	Goa	2	2050
	TOTAL (Western Region)	208	660785
SOUTHERN REGION			
	Kerala	42	227750
	Andhra Pradesh	95	203060
	Karnataka	54	184900
	Tamil Nadu	74	183000
	TOTAL (Southern Region)	265	798710
EASTERN REGION			
	Sikkim	31	191390
	West Bengal	46	126345
	Orissa	28	90375
	Bihar	36	121870
	TOTAL (Eastern Region)	141	529980
NORTH EASTERN REGION			
	Arunachal Pradesh	219	975300
	Mizoram	28	137925
	Manipur	11	47850
	Tripura	5	21510
	Meghalaya	32	151210
	Nagaland	30	142800
	Assam	27	133950
	TOTAL (N E R)	352	1610545
UNION TERRITORY			
	Andaman & Nicobar	1	2250
		1512	**6781810**

Under operation	171	356115
Under construction	86	322310
Investigation completed	171	436685
Identified	1084	5666700
Total	1512	6781810

Rise and Decline of Hydro Share

Year	Installed Capacity (MW)		Hydro as % age of Total
	Total	Hydro	
1947	1361.76	508.13	37.31
1950	1712.52	559.29	32.66
1951	1835.43	575.18	31.34
1952	2061.76	715.18	34.69
1953	2305.19	731.18	31.72
1954	2494.00	793.35	31.81
1955	2694.82	939.48	34.86
1956	2886.14	1061.44	36.78
1957-58	3223.11	1213.92	37.66
1958-59	3511.59	1361.44	38.78
1959-60	3873.17	1530.15	39.51
1960-61	4653.05	1916.66	41.19
1961-62	5218.82	2419.10	46.35
1962-63	5801.19	2936.35	50.62 Maxm.
1963-64	6576.94	3167.02	48.16
1964-65	7396.67	3388.73	45.81
1965-66	9027.02	4123.74	45.68
1966-67	10092.17	4757.22	47.14
1967-68	11888.16	5486.92	46.17
1968-69	12957.27	5906.91	45.59
1969-70	14102.45	6134.70	43.50
1970-71	14708.95	6383.23	43.40
1971-72	15254.37	6611.61	43.34
1972-73	16281.71	6785.41	41.68
1973-74	16663.56	6965.30	41.80
1974-75	18316.68	7529.24	41.11
1975-76	20117.06	8463.60	42.07
1976-77	21468.50	9024.90	42.04
1977-78	23668.71	10020.22	42.34
1978-79	26680.06	10833.07	40.60
1979-80	28447.83	11383.97	40.02
1980-81	30213.68	11791.22	39.02
1981-82	32345.09	12172.81	37.63
1982-83	35363.27	13055.86	36.92
1983-84	39338.86	13855.56	35.23
1984-85	42584.72	14460.02	33.96
1985-86	46769.03	15471.60	33.08
1986-87	49265.86	16195.64	32.87
1987-88	54155.17	17265.33	31.88
1988-89	59040.38	17798.05	30.15
1989-90	63636.34	18307.63	28.77
1990-91	66086.33	18753.42	28.38
1991-92	69065.39	19194.62	27.78
1992-93	72319.46	19568.76	27.05
1993-94	76718.21	20365.91	26.58
1994-95	81164.41	20829.04	25.66
1995-96	83287.96	20976.00	25.18
1996-97	85019.31	21644.80	25.46
1997-98	88266.86	21891.08	24.80
1998-99(8/98)	88543.36	22006.58	24.85

Annexure-4.9

Central/Joint Sector Hydro Power Stations

S.No.	Scheme	Installed Capacity	
		No. of Units x Unit Size (MW)	MW
A. SCHEMES IN OPERATION			
1.	Baria Siul-NIIPC	3 x 60	180
2	Salal-I-NHPC	3 x 115	345
3	Salal-II-NHPC	3 x 115	345
4	Tanakpur-NHPC	3 x 40	120
5	Loktak-NHPC	3 x 35	105
6	Khandong-NEEPCO	2 x 25	50
7	Kopili-NEEPCO	2 x 50	100
8	Chamera St.I. NHPC	3 x 180	540
9	Uri-NHPC	4 x 120	480
10	Kopili Extn. NEEPCO	2 x 50	100
	Total		2365
B. SCHEMES UNDER CONSTRUCTION			
1	Dulhasti-NHPC	3 x 130	390
2	Dhauliganga-I-NHPC	4 x 70	280
3	Koelkaro-NHPC	4 x 172.5+ 1 x 20	710
4	Rangit-NHPC	3 x 20	60
5	Nathpa Jhakri-NJPC	6 x 250	1500
6	Tehri St.-I-THDC	4 x 250	1000
7	Doyang-NEEPCO	3 x 25	75
8	Ranganadi-NEEPCO	3 x 135	405
9	Tuirial-NEEPCO	2 x 30	60
	Total		4480
C. SCHEMES APPROVED BY CEA			
1	Chamera-II-NHPC	3 x 100	300
2	Dhaleshwari-NHPC	3 x 40	120
3	Koteshwar-THDC	4 x 100	400
4	Tehri-II(PSS)-THDC	4 x 250	1000
5	Farakka Barrage-FBPA	5 x 25	125
6	Kameng-NEEPCO	4 x 150	600
	Total		2545
	Gross Total		**9390**

Annexure-4.10

Projects Proposed in Private Sector (in principle clearance accorded)

S. No.	Project	Installed Capacity (MW)	Company/Status
1	Tawa LBC (MP)	12	Hydro electric Graphite Ltd. – Commissioned for 2 x 6.75 MW).
2	Baspa-II (HP)	300	J.P. Industries - CEA cl-19/4/94 (Financial package remains to be tied up)
3	Maheshwar (MP)	400	Sri Maheshwar HPC Ltd.- CEA cl - 30-12-96
4	Vishnu Prayag (UP)	400	J.P. Industries CEA cl-30-6-97
5	Srinagar (UP)	330	Duncan Industries Ltd. - DPR returned
6	Malana (HP)	86	Rajasthan Spinning & Weaving Mills Ltd. Cea cl - 27.7.98 - Under execution
7	Karcham Wangtoo (HP)	1000	Jai Prakash Industries - Returned
8	Dhamwari Sunda (HP)	70	Dhamwari Power Corporation Ltd. Returned
9	Allain Duhangan (HP)	192	Rajasthan Spinning & Weaving Mills Ltd. -Returned
10	Uhl St. III (HP)	100	Ballarpur Industries -Under examination
11	Hibra (HP)	231	Dhamwari Power Corporation - Returned
12	Upper Krishna (Karnatak)	1107	Chamundi Power Corporation Ltd. -Returned
13	Karbi Langpi (Assam)	100	Bharat Hydro Power Corporation -Returned

TOTAL **4328**

Annexure-4.11

Pumped Storage Development in India

S.No.	Scheme	Installed Capacity	
		No. of Units x Unit Size (MW)	MW
A. SCHEMES IN OPERATION			
1.	Kadana St.I & II - Guj.	2 x 60 + 2 x 60	240
2	Paithon - Mah.	1 x 12	12
3	Nagarjuna Sagar - A.P.	7 x 100	700
4	Kadamparai - T.N.	4 x 100	400
5	Panchet Hill - D.V.C.	1 x 40	40
6	Ujjani - Mah.	1 x 12	12
7	Bhira-Mah.	1 x 150	150
	Total		1554
B. SCHEMES UNDER CONSTRUCTION			
1	Sardar Sarovar - Guj.	6 x 200	1200
2	Ghatgar-Mah.	2 x 125	250
3	Srisailam - A.P.	6 x 150	900
4	Purulia - W.B.	4 x 225	900
5	Koyana st - IV - Mah.	4 x 250	1000
6	Bhivpuri - Mah.	1 x 90	90
	Total		4340
C. SCHEMES APPROVED BY CEA			
1	Tehri St. II - U.P.	4 x 250	1000
	Total		6894

Annexure – 5.1

BIS (ISI) Standards for Discharge of Sewage and Industrial Effluents in Surface Water Sources* and Public Sewers

S. No.	Characteristic of the Effluent	Tolerance Limit for Sewage Effluent Discharged into Surface Water Sources as per IS: 4764-1973	Tolerance Limit for Industrial Effluents Discharged Into Inland Surface Waters, as per IS: 2490-1974	Tolerance Limit for Industrial Effluents Discharged Into Public Sewers as per IS: 3306-1974
(1)	(2)	(3)	(4)	(5)
1.	BOD	20 mg/l	30 mg/l	500** mg/l
2.	COD	-	250 mg/l	-
3.	pH value	-	5.5 to 9.0	5.5 to 9.0
4.	Total Suspended Solids (TSS)	30 mg/l	100 mg/l	600 mg/l
5.	Temperature	-	40°C	45°C
6.	Oil and grease	-	10 mg/l	100 mg/l
7.	Phenolic compounds (as Phenol)	-	1 mg/l	5 mg/l
8.	Cyanides (as CN)	-	0.2 mg/l	2 mg/l
9.	Sulphides (as S)	-	2 mg/l	-
10.	Fluorides (as F)	-	2 mg/l	-
11.	Total residual chlorine	-	1 mg/l	-
12.	Insecticides	-	Zero	-
13.	Arsenic (as As)	-	0.2 mg/l	-
14.	Cadmium (as Cd)	-	2 mg/l	-
15.	Chromium, hexavalent (as Cr)	-	0.1 mg/l	2 mg/l
16.	Copper	-	3 mg/l	3 mg/l
17.	Lead	-	0.1 mg/l	1 mg/l
18.	Mercury	-	0.01 mg/l	-
19.	Nickel	-	3 mg/l	2 mg/l
20.	Selenium	-	0.05 mg/l	-
21.	Zinc	-	5 mg/l	15 mg/l
22.	Chlorides (as CI)	-	-	600 mg/l
23.	% Sodium	-	-	60%
24.	Ammoniacal nitrogen (as N)	-	50 mg/l	50 mg/l
25.	Radioactive materials	-		
	(i) α-emitters		10^{-7} μC/ml (micro curie/ml)	-
	(ii) β-emitters		10^{-6} μC/ml	-

** Includes Rivers, Estuaries, Streams, Lakes and Reservoirs.*
*** Subject to relaxation or tightening by the local authorities.*

The Environment (Protection) Rules, 1986
[SCHEDULE – VI]
(See rule 3A)

General Standards for Discharge of Environment Pollutants Part-A Effluents

S. No.	Parameter	Standards			
		Inland Surface Water	**Public Sewers**	**Land for Irrigation**	**Marine Coastal Area**
1	**2**	**3**	**4**	**5**	**6**
1	Colour and odour	See 6 of Ann-1	--	See 6 of Ann-1	See 6 of Ann-1
2	Suspended solids, Mg/l, Max.	100	600	200	a) Fore process waste water-100 b) For coolling water effluent 10 percent above total suspended matter of influent
3	Particular size of Suspended solids	Shall pass 850 micron IS Sieve	--		a) Floatable solids max.3mm b) Settleable solids max. 850 microns
[2]4	...	.	..	..	..
5	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6	Temperature	Shall not exceed 5^0 C above the receiving water temperature	--	--	Shall not exceed 5^0 C above the receiving water temperature
7	Oil and grease, mg/l, Max.	10	20	10	20
8	Total residual Chlorine, mg/l, Max.	1.0	--	--	1.0
9	Ammonical nitrogen (as N), mg/l, Max.	50	50	--	50
10	Total Kjeldahl nitrogen (as N), mg/l, Max.	100	--	--	100
11	Free ammonia (as NH_3), mg/l, Max.	5.0	--	--	5.0
12	Biochamical oxygen demand (5 days at 20^0C), mg/l, Max.	30	350	100	100
13	Chemical Oxygen Demand, mg/l, Max.	250	--	--	250

S. No.	Parameter	Standards			
		Inland Surface Water	Public Sewers	Land for Irrigation	Marine Coastal Area
1	2	3	4	5	6
14	Arsenic (as As), mg/l, Max.	0.2	0.2	0.2	0.2
15	Mercury (As Hg), mg/l, Max.	0.01	0.01	--	0.01
16	Lead (as Pb), mg/l, Max.	0.1	1.0	--	2.0
17	Cadmium (as Cd), mg/l, Max.	2.0	1.0	--	2.0
18	Hexavalent chromium, mg/l, Max.	0.1	2.0	--	1.0
19	Total chromium (as Cr), mg/l., Max.	2.0	2.0	--	2.0
20	Copper (as Cu), mg/l, Max.	3.0	3.0	--	3.0
21	Zinc (as Zn),mg/l, Max.	5.0	15	--	15
22	Selenium (as Se), mg/l, Max.	0.05	0.05	--	0.05
23	Nickel (as Ni), mg/l, Max.	3.0	3.0	--	5.0
[2]24	...	.	.	.	.
[2]25	...	.	.	.	.
[2]26	...	.	.	.	.
27	Cyanide (as CN), mg/l, Max.	0.2	2.0	0.2	0.2
[2]28	...	.	.	.	.
29	Fluoride (as F), mg/l, Max.	2.0	15	--	15
30	Dissolved phosphates (as P), mg/l, Max.	5.0	--	--	--
[2]31	...	.	.	.	.
32	Sulphide (as S), mg/l, Max.	2.0	--	--	5.0
33	Phenolic compounds (as C_6H_5OH), mg/l, Max.	1.0	5.0	--	5.0
34	Radioactive Materials: a) Alpha emitter micro curie/ml b) Beta emitter micro curie/ml	 10^{-7} 10^{-6}	 10^{-7} 10^{-6}	 10^{-8} 10^{-7}	 10^{-7} 10^{-6}

S. No.	Parameter	Standards			
		Inland Surface Water	**Public Sewers**	**Land for Irrigation**	**Marine Coastal Area**
1	**2**	**3**	**4**	**5**	**6**
35	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent
36	Manganese (as Mn),	2 mg/l	2 mg/l	--	2 mg/l
37	Iron (as Fe)	3 mg/l	3 mg/l	--	3 mg/l
38	Vanadium (as V)	0.2 mg/l	0.2 mg/l	--	0.2 mg/l
39	Nitrate Nitrogen	10 mg/l	--	--	20 mg/l
[2]40	..	.	.	.	.

Note : [2] Omitted by Rule 2 (d)(i) of the Environment (Protection) Third Amendment Rules, 1993 vide Notification No. G.S.R. 801 (E) dated 31.12.1993.

Waste Water Generation Standards Part – B

S. No.	Industry	Quantum
1	Integrated Iron & Steel	16 m^3/tonne of finished steel
2	Sugar	0.4 m^3/tonne of cane crushed
3	Pulp & Paper Industries	
	(a) Larger pulp & paper	
	i) Pulp & Paper	175 m^3/tonne of paper produced.
	ii) Viscose Staple Fiber	150 m^3/tonne of product
	iii) Viscose Filament Yarn	500 m^3/tonne of product
	(b) Small pupl & paper:	
	i) Agro-residue based	150 m^3/tonne of paper produced
	ii) Waste paper based	50 m^3/tonne of paper produced
4	Fermentation Industries :	
	(a) Maltry	3.5 m^3/tonne of grain produced
	(b) Brewery	0.25 m^3/ KL of beer produced
	(c) Distillery	12 m^3/ KL of alchol produced
5	Caustic Soda	
	(a) Membrane cell process	1 m^3/tonne of caustic soda produced excluding cooling tower blowdown
	(b) Mercury cell process	4 m^3/tonne of caustic soda produced (mercury bearing) 10% blowdown permitted for cooling tower
6	Textile Industries	
	Man-made fiber	
	i) Nylon & Polyster	120 m^3/tonne of fibre produced
	ii) Vixcose rayon	150 m^3/tonne of product
7	Tanneries	28 m^3/tonne of raw hide
8	Starch, Glucose and related products	8 m^3/tonne of maize crushed
9	Dairy	3 m^3/KL of Milk
10	Natural rubber processing industry	4 m^3/tonne of rubber
11	Fertilizer	
	(a) Straight Nitrogenous fertilizer	5 m^3/tonne of urea or equivalent produced
	(b) Straight phosphatic fertilizer (SSP & TSP) excluding manufacture of acid	0.5 m^3/tonne of SSP/TSP

Annexure – 5.3

GROSSLY POLLUTED AND LESS POLLUTED STRETCHES OF SOME MAJOR RIVERS

Basin	River/ Tributary	Polluted Stretch Class	Existing Class	Desired Parameter	Critical
I. GROSSLY POLLUTED STRETCHES					
Indus	Sutlej	i) Downstream (D/S) Ludhiana to Harike ii) D/S of Nangal	Partly D Partly E E	C C	DO, BOD. Ammonia
Ganga	Yamuna	i) Delhi to confluence with Chambal ii) In the city limits of Delhi, Agra and Mathura	Partly D Partly E -do-	C C	DO, BOD. Coliforms -do-
	Chambal	D/S of Nagda & D/S of Kota (approx 15 km both the places)	Partly D Partly E	C	BOD, Do.
	Damodar	D/S of Dhanbad to Haldia	Partly D Partly E	C	BOD, Toxic
	Gomti	Lucknow to confluence with Ganga	Partly D Partly E	C	DO, BOD. Coliforms
	Kali	D/S of Modinagar to confluence with Ganga	Partly D Partly E	C	-do-
	Khan	i) In the city limits of Indore ii) D/S of Indore	E E	B D	-do- -do
	Kshipra	i) In the city limits of Ujjain ii) D/S of Ujjain	E E	B D	-do- -do-
	Hindon	Saharanpur to confluence with Yamuna	E	D	DO,BOD Toxic
Godavari	Godavari	i) D/S of Nasik to Nanded ii) City limits of Nasik and Nanded	Partly D Partly E -do-	C B	BOD BOD
Krishna	Krishna	Karad to Sngli	Partly D Partly E	C	BOD
Suberna-rekha	Suberna-rekha	Hathi Dam to Baharagora	Partly D Partly E	C	DO, BOD Coliforms
Sabar-mati	Sabar-mati	i) Immediate upstream of Ahmedabad city upto Sabarmati Asharm, ii) Sabarmati Asharam to Veutha	E	B	DO, BOD Coliforms

II. LESS GROSSLY POLLUTED STRETCHES

Ganga	Betwa	Between Vidisha and Mandideep and Bhopal (MP)	D	C	BOD, Total Coliforms
Krishana	Krishana	i) Dhom Dam to Narso Babri (Mah) ii) Tributary Streams iii)Upto Nagarjunasagar Dam, from that Dam to Upstream of Repella (A.P.)	D D D	C C C	BOD & Coliforms -do- -do-
	Bhadra	Origin to downstream of KICCL of Bhadra Dam (Karnataka)	D	C	Total Coliforms
	Tunga	Thirthahalli to contluence with Bhadra	C	C	Total Coliforms
Cauvery	Cauvery	i) From Talakaveri to 5 km of Mysore District Border Yagni (Karnataka) ii) From Krishna Raj Sagar Dam to Hogenekkal (Karnataka) iii) From Pugalur to Grand Anicut (Tamil Nadu) iv) Grand Anicut to Kumbhakonam (Tamil Nadu)	C E E E	A C C C	Total Coliforms DO, BOD, Coliforms BOD, Total Coliforms Total Coliforms
Brahmani Baitarni	Baitarni	Upstream of Chandbali	D	B	BOD, & Coliforms
	Brahmani	Upstream of Dharmshalla	D	B	BOD & Coliforms
Tapi	Tapi	From city limits of Nepanagar to the City of Burhanpur (MP)	E	A	DO, BOD

Annexure – 5.4

Test Characteristics for Drinking Water (IS: 10500 - 1991)

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect Outside The Desirable Limit	Permissible Limit In the Absence of Alternate Source	Methods of Test (Ref To IS)	Remarks
1	2	3	4	5	6	7
			Essential Characteristics			
(i)	Colour, Hazen Units, Max.	5	Above 5, consumer Acceptance Decreases.	25	3025 (Part 4) : 1983	Extended to 25 only if toxic substances are not suspected, in absence of alternate sources.
(ii)	Odour	Unobjectionable	-	-	3025 (Part 5) : 1983	a) Test cold and when heated b) Test at several dilutions
(iii)	Taste	Agreeable	-	-	3025 (Parts 7 and 8) : 1984	Test to be conducted only after safety has been established
(iv)	Turbidity, N.T.U., *Max.*	5	Above 5, consumer acceptance decreases.	10	3025 (Part 10) : 1984	-
(v)	PH	6.5 to 8.5	Beyond this range, the water will affect the macous membrane and /or water supply system.	No relaxation	3025 (Part II) : 1984	-
(vi)	Total hardness (as $CaCO_3$), mg/l, *Max.*	300	Encrustation in water supply structure and adverse effects on domestic use.	600	3025 (Part 21) : 1983	-
(vii)	Iron (as Fe), mg/l, *Max.*	0.3	Beyond this limit, taste/appearance are affected. Effect on domestic uses and water supply structures, and promotes iron bacteria.	1.0	32 of 3025 ; 1964	-

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect Outside The Desirable Limit	Permissible Limit In the Absence of Alternate Source	Methods of Test (Ref To IS)	Remarks
1	2	3	4	5	6	7
(viii)	Chlorides (as Cl), mg/l, *Max.*	250	Beyond this limit, taste, corrosion and palatability are affected.	1000	3025 (Part 32) : 1988	-
(ix)	Residual, free chlorine, mg/l, *Min.*	0.2	-	-	3025 (Part 26) : 1986	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be *Min* 0.5 mg/l
			Desirable Characteristics			
(x)	Dissolved solids, mg/l, Max.	500	Beyond this, palatability decreases and may cause gastro intestinal irritation.	2000	3025 (Part 16) : 1984	-
(xi)	Calcium (as Ca), mg/l, Max.	75	Encrustation in water supply structure and adverse effects on domestic use.	200	3025 (Part 40) : 1991	-
(xii)	Magnesium, mg/l, Max.	30	Encrustation in water supply structure and adverse effects on domestic use.	100	36 of 3025 : 1964	-
(xiii)	Copper (as Cu), mg/l, Max.	0.05	Astringent taste, discoloration and corrosion of pipes, fitting and utensils will be caused beyond this.	1.5	36 of 3025 : 1964	-
(xiv)	Manganese (as Mn), mg/l, Max.	0.1	Beyond this limit, taste/ appearance are affected, has adverse effect on domestic uses and water supply structures.	0.3	35 of 3025 : 1964	-
(xv)	Sulphate (as SO_4), mg/l, Max.	200	Beyond this, causes gastro intestinal irritation when magnesium or sodium are present.	100	3025 (Part 24) : 1986	

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect Outside The Desirable Limit	Permissible Limit In the Absence of Alternate Source	Methods of Test (Ref To IS)	Remarks
1	2	3	4	5	6	7
(xvi)	Nitrate (as NO_3), mg./l, Max.	45	Beyond this, methaemonglobiemia takes place.	100	3025 (Part 34) : 1988	-
(xvii)	Fluoride (as F), mg/l, Max.	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis.	1.5	23 of 3025 : 1964	-
(xviii)	Phenolic compounds (as $C_6H_5(OH)$, mg/l, Max.	0.0001	Beyond this, it may cause objectionable taste and odour.	0.002	54 of 3025 : 1964	-
(xix)	Mercury (as Hg), mg/l, Max.	0.0001	Beyond this, the water becomes toxic.	No relaxation	(see Note) Mercury ion analyser	To be tested when pollution is suspected.
(xx)	Cadmium (as Cd), mg/l, max.	0.01	Beyond this, the water becomes toxic.	No relaxation	(see Note)	To be tested when pollution is suspected.
(xxi)	Selenium (as Se), mg/l, Max.	0.01	Beyond this, the water become toxic.	No relaxation	28 of 3025 : 1994	To be tested when pollution is suspected.
(xxii)	Arsenic (as As), mg/l, Max.	0.05	Beyond this, the water become toxic.	No relaxation	3025 (Part 37) : 1988	To be tested when pollution is suspected.
(xxiii)	Cyanide (as CN), mg/l, Max.	0.05	Beyond this, the water become toxic.	No relaxation	3025 (Part 27): 1986	To be tested when pollution is suspected.
(xxiv)	Lead (as Pb), mg/l, Max.	0.05	Beyond this limit, the water become toxic.	No relaxation	(see Note)	To be tested when pollution/plumbo-solyrany is suspected.
(xxv)	Zinc (as Zn), mg/l, Max.	5	Beyond this limit, it can cause astringent taste and an opalescence in water.	15	39 of 3025 : 1964	To be tested when pollution is suspected.
(xxvi)	Anionic detergents (as MBAS), mg/l, Max.	0.2	Beyond this limit, it can cause a light forth in water.	1.0	Methylene – blue extraction method	To be tested when pollution is suspected.
(xxvii)	Chromium (as Cr), Mg/l, Max.	0.05	May be carcinogenic above this limit.	No relaxation	38 of 3025 : 1964	To be tested when pollution is suspected.

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect Outside The Desirable Limit	Permissible Limit In the Absence of Alternate Source	Methods of Test (Ref To IS)	Remarks
1	2	3	4	5	6	7
(xxviii)	Polynuclear aromatic hydrocarbons (as PAH) Mg/l, Max.	0.2	May be carcinogenic.	-	-	-
(xxix)	Mineral oil, Mg/l, Max.	0.01	Beyond this limit, undesirable taste and odour after chlorination take place.	0.03	Gas chromatographic method	To be tested when pollution is suspected.
(xxx)	Pesticides, Mg/l, Max.	Absent	Toxic	0.001	-	-
(xxxi)	Radioactive Materials: a) Alpha emiters pci/l, Max b) Beta emiters pci/l, Max.	-	-	0.1	-	-
(xxxii)	Alkalinity, mg/l, Max.	200	Beyond this limit, taste becomes unpleasant.	6001	13 of 3025: 1964	-
(xxxiii)	Aluminium (as Al), mg/l, Max.	0.03	Cumulative effect is reported to cause dementia.	0.2	31 of 3025 : 1964	-
(xxxiv)	Boron, mg/l, Max.	1	-	5	29 of 3025 : 1964	-

NOTE : Atomic absorption spectrophotometric method may be used.

None of the generally accepted sewage treatment methods yield virus-free effluent. Although a number of investigators have found activated sludge treatment to be superior to trickling filters from this point of view, it seems possible that chemical precipitation methods will prove to be the most effective.

Virus can be isolated from raw water and from springs. Enterovirus, reovirus and adenovirus have been found in water, the first named being the most resistant to chlorination. If enterovirus are absent from chlorinated water, it can be assumed that the water is safe to drink. Some uncertainty still remains about the virus of infectious hepatitis, since it has not so far been isolated but in view of the morphology and resistance of enterovius it is likely that, if they have been inactivated, hepatitis virus will have been inactivated also.

An exponential relationship exists between the rate of virus inactivation and the redox potential. A redox potential of 650 mV (measured between platinum and calomel electrodes) will cause almost instantaneous inactivation of even high concentrations of virus. Such a potential can be obtained with even a low concentration of free chlorine, but only with an extremely higher concentration of combined chlorine. This oxidative inactivation may be achieved with a number of other oxidants also, for example, iodine, ozone, and potassium permangante, but the effect of the oxidants will always be counteracted if reducing components, which are mainly organic, are present. As a consequence, the sensitivity of virus towards disinfectants will depend on the milieu just as much as on the particular disinfectant used.

Thus, in a water in which free chlorine is preset, active virus will generally be absent if coliform organisms are absent. In contrast, because the difference between the resistance of coliform organisme and of virus to disaffection by oxidants increased with increasing concentration of reducing components, for example, ongoing matter, it cannot be assumed that the absence of viable coliform organisms implies freedom from active virus under circumstances where a free chlorine residual cannot be maintained. Sedimentation and slow sand filtration in themselves may contribute to the removal of virus from water.

In practice, 0.5 mg/l of free chlorine for one hour is sufficient to inactivate virus, even in water that was originally polluted.

Biological examination is of value in determining the causes of objectionable tastes and odours in water and controlling remedial treatments, in helping to interpret the results of various chemicals analysis, and in explaining the causes of clogging in distribution pipes and filters. In some instances, it may be of use in demonstrating that water from one source has been mixed with that from another.

The biological qualities of a water are of greater importance when the supply has not undergone the conventional flocculation and filtration processes, since increased growth of methane-utilizing bacteria on biological slimes in pipes may then be expected, and the development of bryozoan growths such as Plumatclla may cause operational difficulties.

Some of the animalcules found in water mains may be free-living in the water, but other such as Dreissena and Asellus are more or less firmly attached to the inside of the mains. Althrough these animalcules are not themselves pathogenic, they may harbour pathogenic organisms or virus in their intestines, thus protecting theses pathogens form destruction by chlorine.

Chlorination, at the dosages normally employed in waterworks, is ineffective against certain parasites, including amoebic cysts; they can be excluded only by effective filtration or by higher chlorine doses than can be tolerated without subsequent dechlorination. Amoebiasis can be conveyed by water completely free from enteric bacteria, microscopic examination after concentration is, therefore, the only safe method of identification.

Strict precautions against back syphonage and cross connection are required if amoebic cysts are found in a distribution system containing tested water.

The cereariae of schistosomiasis can be detected by similar micro-scopic examination, but there is in any case no evidence to suggest that this disease is normally spread through piped water supplies.

The cyclops vector the embryos of.which causes dracontiatis or Guinea-worm disease can be found in open wells in a number of tropical areas. They are identifiable by micro-scopic examination. Such wells supplies are frequently used but the parasite can be relatively easily excluded by simple physical improvement in the form of curbs drainage and apron surround and other measures which prevent physical contact with the water resources.

The drinking water shall be free from micro-scopic organisms such as algae, zooplanktons, flagillattes, parasites and toxin – producing organisms.

Projected Production of Various Sectors of Indian Industries

S.No.	Category of Industry	Unit	Production Figures					
			Year 1997	Growth Rate, %	Year 2000	Year 2010	Year 2025 Normal	Year 2050 Normal
1	2	3	4	5	6	7	8	9
1	Integrated Iron & Steel	1000 Tonnes	119.390	9.20	174,050	265,350	273,300	547,050
2	Smelters	1000 Tonnes	174	5.80	203.6	292.6	391.60	537.60
3	Petrochemicals and Refinary	1000 Tonnes	1.255	3.20	1,381	1,800.59	2,221	3,271
4	Chemicals-Causic Soda	1000 Tonnes	1,459.30	21.40	1,600	1,854.55	2,303.50	3,467.70
5	Textile & Jute	1000 Tonnes	24,730.20	11.57	51,193	95,093.90	183,507	234,617.5
6	Cement	1000 Tonnes	76,000	11.01	120,000	219,000	395,000	749,000
7	Fertilizer	1000 Tonnes	11,155.30	8.00	17,300	37,782	66,173.33	88,351.70
8	Leather Products	1000 Tonnes	912.5	5.800	1,277.50	2,191.25	3,102.50	4,927.50
9	Rubber	1000 Tonnes	403.24	5.75	479.96	651.5	971.46	1,445
10	Food Processing	1000 Tonnes	96,450	13.90	124,223	506,150	1,,386.730	1,808,576
11	Inorganic Chemicals	1000 Tonnes	2,200	6.80	3,730	8,000	16,730	30,076
12	Sugar	1000 Tonnes	14,500	12.20	19,500	32,350	152,000	289,500
13	Pharmaceuticals	1000 Tonnes	4,190.00	11.90	4,960.00	8370	11,046	17,170
14	Distillary (Req. Per 1000 litres)	Million Tonnes	1,790.80	4.20	1,790.80	3,059.59	4,454.60	6,020
15	Pesticides	1000 Tonnes	86	7.30	195.3	306.15	742.05	1,288.8
16	Paper & Pulp	1000 Tonnes	3,100	4.30	4,950	10,350	51,200	97,450
17	General Engineering	1000 Tonnes	5,779	11.90	6,514.50	10,,754	12,643.50	25,287
	Total			**9.07**				

Annexure - 5.6

Projecated Pollution Load Generation of Various Sectors of Indian Industries

S.No.	Category of Industry	Waste Water Generation m³/tonnes/year	Year 1997		Year 2000		Year 2010		Year 2025		Year 2050	
			Production 1000 tonnes	Waste Water Generation Mm³/year	Production 1000 tonnes	Waste Water Generation Mm³/year	Production 1000 tonnes	Waste Water Generation Mm³/year	Production 1000 tonnes	Waste Water Generation Mm³/year	Production 1000 tonnes	Waste Water Generation Mm³/year
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Integrated Iron & Steel	16	119.390	763.80	174,050	2,784.80	265,350	4,245.60	273,300	4,372.80	547,050	8752.80
2	Smelters	65	174	9.50	203.6	13.23	292.6	19.02	391.60	25.45	537.60	34.95
3	Petrochemicals and Refinary	13.0	1.255	16.30	1,381	17.95	1,800.59	23.41	2,221	28.87	3,271	42.52
4	Chemicals-Causic Soda	1.0	1,459.30	1.43	1,600	1.60	1,854.55	1.85	2,303.50	2.30	3,467.70	3.47
5	Textile & Jute	150	24,730.20	589.00	51,193	7,678.95	95,093.90	14,264.06	183,507	27,526.05	234,617.5	35192.63
6	Cement	NA	76,000	-	120,000	-	219,000	-	395,000	-	749,000	-
7	Fertilizer	3.5	11,155.30	51.50	17,300	60.65	37,782	132.24	66,173.33	231.61	88,351.70	309.23
8	Leather Products	28.0	912.5	21.00	1,277.50	35.77	2,191.25	61.36	3,102.50	86.87	4,927.50	137.97
9	Rubber	5.0	403.24	2.00	479.96	2.40	651.5	3.26	971.46	4.86	1,445	7.23
10	Food Processing	NA	96,450	-	124,223	-	506,150	-	1,,386.730	-	1,808,576	-
11	Inorganic Chemicals	4	2,200	70.40	3,730	14.92	8,000	32.00	16,730	66.92	30,076	120.31
12	Sugar	0.4	14,500	5.30	19,500	7.80	32,350	12.94	152,000	60.80	289,500	115.80
13	Pharmaceuticals	NA	4,190.00	83.80	4,960.00	-	8370	-	11,046	-	17,170	-
14	Distillary (Req. Per 1000 litres)	12	1,790.80	40.15	1,790.80	21.49	3,059.59	1.53	4,454.60	53.46	6,020	206.04
15	Pesticides	5.0	86	3.08	195.3	0.98	306.15	1,811.25	742.05	37.10	1,288.8	6.45
16	Paper & Pulp	175	3,100	830.00	4,950	866.25	10,350	1,811.25	51,200	8,960.00	97,450	17053.75
17	General Engineering	175.0	5,779	1,016.00	6,514.50	1,140.04	10,,754	1,881.95	12,643.50	2,212.61	25,287	4425.23
	Total			**3,503.26**		**12,646.83**		**24,301.72**		**43,669.70**		**66408.38**

Projected Water Requirement of Various Sectors of Indian Industries

S.No.	Category of Industry	Water/ Unit m^3/tonnes/year	Year 1997		Year 2000		Year 2010		Year 2025		Year 2050	
			Production 1000 tonnes	Water Req. Mm^3/year	Production 1000 tonnes	Water Req. Mm^3/year	Production 1000 tonnes	Water Req. Mm^3/year	Production 1000 tonnes	Water Req. Mm^3/year	Production 1000 tonnes	Water Req. Mm^3/year
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Integrated Iron & Steel	22	119.390	2626.58	174,050	3,829.10	265,350	5,837.70	273,300	6,012.60	547,050	12035.10
2	Smelters	82.5	174	14.36	203.6	16.76	292.6	24.14	391.60	32.31	537.60	44.35
3	Petrochemicals and Refinary	17.0	1.255	21.34	1,381	23.47	1,800.59	30.61	2,221	37.76	3,271	55.61
4	Chemicals-Causic Soda	5.5	1,459.30	8.03	1,600	8.65	1,854.55	10.20	2,303.50	12.67	3,467.70	19.07
5	Textile & Jute	200	24,730.20	4,863.02	51,193	8,153.72	95,093.90	19,018.78	183,507	36,701.40	234,617.5	46923.50
6	Cement	4.5	76,000	418.00	120,000	599.50	219,000	985.50	395,000	1,777.50	749,000	3370.50
7	Fertilizer	16.7	11,155.30	147.51	17,300	220.11	37,782	630.96	66,173.33	1,105.09	88,351.70	1192.75
8	Leather Products	30	912.5	30.12	1,277.50	1,244.65	2,191.25	65.74	3,102.50	93.08	4,927.50	147.83
9	Rubber	6.6	403.24	2.66	479.96	3.04	651.5	4.30	971.46	6.41	1,445	9.54
10	Food Processing	6.8	96,450	848.76	124,223	991.76	506,150	3,441.82	1,,386.730	9,442.76	1,808,576	12298.32
11	Inorganic Chemicals	200	2,200	96.80	3,730	165.44	8,000	1,600.00	16,730	3,346.00	30,076	615.20
12	Sugar	2.2	14,500	36.21	19,500	46.20	32,350	71.17	152,000	334.40	289,500	636.90
13	Pharmaceuticals	25	4,190.00	104.75	4,960.00	124.00	8370	209.25	11,046	276.15	17,170	429.15
14	Distillary (Req. Per 1000 litres)	22	1,790.80	3,939.76	1,790.80	6,357.20	3,059.59	66.31	4,454.60	318.00	6,020	5203.92
15	Pesticides	6.5	86	3.78	195.3	6.67	306.15	1.99	742.05	4.82	1,288.8	8.38
16	Paper & Pulp	200	3,100	852.50	4,950	1,259.50	10,350	207.00	51,200	10,240.00	97,450	19490.00
17	General Engineering	2.2	5,779	127.38	6,514.50	1,433.20	10,,754	23.66	12,643.50	27.82	25,287	55.63
	Total			**14,141.56**		**24,482.97**		**32,229.13**		**69,768.77**		**102535.75**

The Environment (Protection) Rules, 1986

ANNEXURE

GUIDELINES FOR PERMITTING/RESTRICTING INDUSTRIES AND INDUSTRIAL UNITS IN THE DAHANU TALUKA, THANE DISTRICT IN MAHARASHTRA

Industries will be classified under three categories viz. Green, Orange and Red as shown below for the purpose of permitting/restricting such industrial activities in Dahanu Taluka on the basis of environmental and ecological 'considerations'. In case of doubts as to the category in which an industry falls, references shall be made to the Ministry of Environment & Forests, Government of India, and such industry will not be permitted until cleared by the Ministry of Environment & Forests, Government of India.

GREEN CATEGORY

List of industries that can be considered by the Maharashtra government agencies for approval/rejection in approved industrial areas without prior approval of the Ministry of Environment & Forests, Government of India (provided that all the following conditions are satisfied) :

1. Only those industries that are non –obnoxious and non-hazardous will be permitted. (Obnoxious and hazardous industries include those using inflammable, explosive, corrosive or toxic substances).

2. Only those industries that do not discharge industrial effluents of a polluting nature will be permitted.

Note : Industries that undertake any of the following processes or process of similar nature shall be regarded as industries that discharge industrial effluents of a polluting nature, namely :

Electroplating

Galvanizing

Bleaching

Degreasing

Phosphating

Dyeing

Pickling

Tanning

Polishing

Cooking of fibres

Digesting of hides.

Desizing of fabrics

Removal of hair, soaking, deliming and washing of fabric

Distillation of alcohol, stillage evaporation

Slaughtering of animals, rendering of bones, washing of meat :

Crushing of sugarcane, filtration, centrifugation, distillation for extraction of sugar.

Filtering backash in D.M. Plants

Pulp making, pulp processing and paper making

Cooking of coal

Stripping of oxides

Washing of used sand by hydraulic discharge

Washing extraction.

3. Only those industries that do not use coal in their manufacturing process will be permitted.

4. Only those industries that do not emit fugitive emissions of a diffused nature will be permitted.

Note : (1) Some of the industries that ordinarily fall in the non-obnoxious, non-hazardous and non-polluting category, subject to fulfillment of above conditions are :

Rice Mills, Dal Mills, Grain Mills (for production of flour) ;

Manufacture of Supari and masala grinding ;

Groundnut decorating (dry) ;

Chilling Plants and cold storage ;

Ice making ;

Preservation of Meat, canning, preserving and processing of fish, crustaceans and similar foods ;

Manufacture of milk and dairy products such as butter, ghee etc ;

Book binding ;

Engraving, etching, block making ;

Manufacture of structural stone goods, stone dressing and polishing (stone crushing/stone quarrying will not be permitted) ;

Manufacture of metal building component such as grills, gates, doors and window frames, water tanks, wire nets etc. (use of coal not permitted) ;

Tool sharpening works ;

Repairs of electrical appliances ;

Manufacture of push carts, hand carts, bullock carts etc. ;

Manufacture of jewellery and related articles (no power to be used);

Repairs of Watches, Clocks, Jewellery;

Manufacture of bidis ;

Handlooms/Powerlooms, subject to the maximum of 4 looms ;

Embroidery and the making of laces and fringes ;

Manufacture of made up textile goods such as curtains, mosquito nets, mattresses, bedding material, pillow cases, bags etc ;

Readymade garments and Apparel making (dry processing);

Cotton and woolen hosiery (dry processing);

Handloom weaving ;

Manufacture of leather foot wear and leather products (excluding tanning and hide processing) ;

Shoe lace manufacturing ;

Manufacture of mirrors and photoframes ;

Manufacture of musical instruments ;

Manufacture of sports goods ;

Manufacture of bamboo and cane products (dry operation only);

Manufacture of cardboard and paper products (Paper and pulp manufacture excluded) ;

Insulation and other coated papers (Paper and pulp manufacture excluded) ;

Manufacture of scientific and mathematical instruments ;

Manufacture of furniture (Wood only) ;

Assembly of domestic electrical and electronic appliances ;

Manufacture of writing instruments (pens, pencils etc.) ;

Extrusion moulding of polythene, plastic and PVC goods ;

Manufacture of surgical gauzes and bandages;

Manufacture of concrete railway sleepers ;

Cotton spinning and weaving (dry processes only) ;

Manufacture of ropes (cotton, jute, plastic) ;

Carpet weaving ;

Manufacture of wires and pipes (non-asbestos) ;

Extrusion of metal ;

Assembly of electric and electronic equipment ;

Coir industries ;

Toys ;

Wax candles and agarbattis ;

Oil-ginning and expelling (no hydrogenation and no refining) ;

Manufacture of ice –cream ;

Manufacture of mineral water ;

Manufacture of trunks and suitcases ;

Manufacture of stationery items (except paper and inks);

Manufacture of optical frames ;

(2) The inclusion of industries in this list is for convenience and if in a given case they do not fall in the above category, they will be treated as in the Orange or red Categories.

ORANGE CATEGORY

List of industries that can be permitted in Dahanu Taluka with proper environmental Assessment and adequate Pollution Control Measures in sites that have been approved by the Ministry of Environment & Forests, Government of India.

Ceramics ;

Sanitary ware ;

Flourmills ;

Vegetable oils including solvent extracted oils ;

Soap (without steam boiling process);

Formulation of synthetic detergents (non-phosohatic);

Steam generating plants (without coal/coke) ;

Manufacture of office and household furniture and appliances ;

Manufacture of machinery and machine tools and equipments ;

Manufacture of industrial gases (only Nitrogen, Oxygen and CO_2);

Glassware using fuel other than coal/coke ;

Optical Glass ;

Laboratoryware ;

Surgical and Medical products, excluding prophylactics and latex products ;

Rubber foot wear ;

Bakery products, biscuits and confectionery ;

Instant Tea/Coffee ;

Malt foods ;

Manufacture of pumps, compressors, refrigeration units, fire fighting equipment etc.;

Wire drawing (cold process), Wire Nails, Balling Straps ;

Steel furniture ;

Medical and surgical instruments;

Fragrances, flavours and food additives ;

Organic plants nutrients ;

Aerated water/soft drinks ;

Industries falling within the above category with an outlay exceeding Rs. 3 crores will have to be referred to the Ministry of Environment and forests, Government of India for consideration.

RED CATEGORY

List of industries that cannot be permitted in Dahanu Taluka
The illustrative list of industries that fall within this category includes :

Metallurgical industries including foundries and alloy making processes ;

Coal and other mineral processing industries ;

Cement Plants ;

Industries based on the use of coal/coke;

Refineries ;

Petrochemical industries ;

Synthetic Rubber Manufacture ;

Thermal and nuclear power plants ;

Manufacture of vanaspati, hydrogenated vegetable oils for industrial purposes ;

Sugar Mills ;

Manufacture of Paper and Pulp (including News Print) ;

Manufacture of by-products of coke ovens and coal tar distillation products ;

Alkalis and acids ;

Electro-thermal products (such as artificial abrasives, calcium carbide etc.);

Phosphorus and its compounds ;

Nitrogen compounds ;

Explosives ;

Fire-crackers ;

Pthalic anhydride ;

Processes involving chlorinated hydrocarbons ;

Chlorine, fluorine, bromine, iodine and their compounds ;

Chemical fertilizers ;

Synthetic fibres and rayon ;

Manufacture and formulation of synthetic pesticides/insecticides/bactericides/fugicides etc.;

Basic drug ;

Alcohol ;

Tanning and processing of animal, skins, hides, leather etc. ;

Making of coke, liquifaction of coal ;

Manufacture of fuel gas ;

Fibre glass production or processing ;

Dyes and their intermediates ;

Industrial carbon and carbon products ;

Electro-chemical and their products ;

Paints, enamels and varnishes ;

Poly vinyl chlorides ;

Polypropylene ;

Chlorates, per chlorates and peroxides ;

Polishes ;

Synthetic resins ;

Plastics ;

Asbestos ;

Note : In case of industries which do not fall in any of the above mentioned three categories, decision in regard to their classification will be taken by the State Government for those projects having an outlay not exceeding Rs. 3 crores and for others, reference is to be made to the Ministry of Environment and Forests, Government of India.

Annexure-7.1

Irrigation Water Depth and Return Flow
Mahanadi Basin

S. No.	Sub-Basin	Station	Average NIR	Average GIR		Return Flow 0.6 (GIR - NIR)		Return Flow 0.8 (GIR - NIR)	
				SW	GW	SW	GW	SW	GW
			(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	2	3	4	5	6	7	8	9	10
1	Sheonath	Raipur	0.185	0.648	0.519	0.28	0.20	0.37	0.27
2	Jonk	Titlagarh	0.167	0.704	0.563	0.32	0.24	0.43	0.32
3	Hasdeo	Champa	0.137	0.588	0.471	0.27	0.20	0.36	0.27
4	Mand	Raigarh	0.203	0.695	0.556	0.30	0.21	0.39	0.28
5	Ib	Sambalpur	0.174	0.700	0.560	0.32	0.23	0.42	0.31
6	Upper	Kankar and Raipur	0.169	0.63	0.504	0.28	0.20	0.37	0.27
7	Ong	Titlagarh Sambalpur	0.116	0.563	0.451	0.27	0.20	0.36	0.27
8	Tel	Titlagarh	0.175	0.668	0.535	0.30	0.22	0.39	0.29
9	Middle	Bolangir	0.169	0.737	0.590	0.34	0.25	0.45	0.34
10	Lower	-	0.177	0.777	0.620	0.36	0.27	0.48	0.35
		Total	**1.67**	**6.71**	**5.37**	**3.04**	**2.22**	**4.02**	**2.96**
		Avg.	**0.17**	**0.67**	**0.54**	**0.30**	**0.22**	**0.40**	**0.30**
		%age.				**45.31**	**41.31**	**59.91**	**55.09**

Annexure-7.1

Irrigation Water Depth and Return Flow
Godavari Basin

S. No.	Sub-Basin	Station	Average NIR	Average GIR		Return Flow 0.6 (GIR - NIR)		Return Flow 0.8 (GIR - NIR)	
				SW	GW	SW	GW	SW	GW
			(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	2	3	4	5	6	7	8	9	10
1	Upper	Ahmednagar	0.235	0.47	0.38	0.14	0.09	0.19	0.12
		Aurangabad							
2	Pravara	Ahmednagar	0.228	0.547	0.438	0.19	0.13	0.26	0.17
3	Purna	Aurangabad	0.249	0.580	0.465	0.20	0.13	0.26	0.17
4	Manjara	Bidar	0.214	0.44	0.35	0.14	0.08	0.18	0.11
		Hyderabad							
		Nizamabad							
5	Middle	Nizamabad	0.210	0.66	0.52	0.27	0.19	0.36	0.25
		Ramagundam							
6	Maner	Hanam	0.216	0.70	0.56	0.29	0.21	0.39	0.28
		Konda							
7	Penganga	Yeotmal	0.206	0.47	0.37	0.16	0.10	0.21	0.13
8	Wardha	Chanda	0.174	0.45	0.36	0.17	0.11	0.22	0.15
		Yeotmal							
9	Pranhita	Chindwara	0.173	0.61	0.49	0.26	0.19	0.35	0.25
10	Lower	Kakinada	0.178	0.60	0.48	0.25	0.18	0.34	0.24
11	Indravati	Jagdalpur	0.190	0.609	0.49	0.25	0.18	0.34	0.24
		Sironcha							
12	Sabri	Jagdalpur	0.142	0.614	0.491	0.28	0.21	0.38	0.28
		Total	**2.42**	**6.75**	**5.39**	**2.60**	**1.80**	**3.48**	**2.39**
		Avg.	**0.20**	**0.56**	**0.45**	**0.22**	**0.15**	**0.29**	**0.20**
		%age.				**38.53**	**33.37**	**51.56**	**44.31**

Annexure-7.1

Irrigation Water Depth and Return Flow
Krishna Basin

S. No.	Sub-Basin	Station	Average NIR	Average GIR		Return Flow 0.6 (GIR - NIR)		Return Flow 0.8 (GIR - NIR)	
				SW	GW	SW	GW	SW	GW
			(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	2	3	4	5	6	7	8	9	10
1	Upper	Miraj	0.252	0.56	0.45	0.18	0.12	0.25	0.16
		Kolhapur							
2	Middle	Bijapur	0.266	0.52	0.418	0.15	0.09	0.20	0.12
3	Ghataprabha	Balgaum	0.20	0.44	0.351	0.14	0.09	0.19	0.12
4	Malaprabha	Godag	0.240	0.51	0.40	0.16	0.10	0.22	0.13
		Balgaum							
5	Upper Bhima	Ahmednagar	0.289	0.52	0.418	0.14	0.08	0.18	0.10
		Pune							
		Sholapur							
6	Lower Bhima	Gulbarga	0.293	0.612	0.49	0.19	0.12	0.26	0.16
7	Lower Krishna	Raichur	0.292	0.82	0.66	0.32	0.22	0.42	0.29
		Kurnool							
8	Tungbhadra	Gadag	0.251	0.65	0.52	0.24	0.16	0.32	0.22
		Raichur							
		Bellry							
		Shimoga							
9	Vedavati	Chitradurga	0.305	0.704	0.56	0.24	0.15	0.32	0.20
		Ballry							
10	Musi	Hyderabad	0.228	0.63	0.50	0.24	0.16	0.32	0.22
11	Palleru	Khammam	0.183	0.64	0.51	0.27	0.20	0.37	0.26
12	Muneru	Khammam	0.175	0.54	0.43	0.22	0.15	0.29	0.20
		Total	**2.97**	**7.15**	**5.71**	**2.50**	**1.64**	**3.34**	**2.19**
		Avg.	**0.25**	**0.60**	**0.48**	**0.21**	**0.14**	**0.28**	**0.18**
		%age.				**35.03**	**28.73**	**46.71**	**38.31**

Pennar Basin

S. No.	Sub-Basin	Station	Average NIR	Average GIR SW	Average GIR GW	Return Flow 0.6 SW	Return Flow 0.6 GW	Return Flow 0.8 SW	Return Flow 0.8 GW
1	Upper	Anantpur	0.348	0.812	0.650	0.28	0.18	0.37	0.24
2	Middle	Kurnool &	0.311	0.790	0.630	0.29	0.19	0.38	0.26
		Cuddapaha							
3	Lower	Cuddapaha	0.209	0.545	0.436	0.20	0.14	0.27	0.18
		Anegyavaran							
4	Delta	Cuddapha &	0.293	0.860	0.68	0.34	0.23	0.45	0.31
		Nellore							
		Total	**1.16**	**3.01**	**2.40**	**1.11**	**0.74**	**1.48**	**0.99**
		Avg.	**0.29**	**0.75**	**0.60**	**0.28**	**0.19**	**0.37**	**0.25**
		%age.				**36.83**	**30.93**	**49.11**	**41.24**

Annexure-7.1

Irrigation Water Depth and Return Flow
Cauvery Basin

S. No.	Sub-Basin	Station	Average NIR (m)	Average GIR SW (m)	Average GIR GW (m)	Return Flow 0.6 (GIR - NIR) SW (m)	Return Flow 0.6 (GIR - NIR) GW (m)	Return Flow 0.8 (GIR - NIR) SW (m)	Return Flow 0.8 (GIR - NIR) GW (m)
1	2	3	4	5	6	7	8	9	10
1	Upper	Mercara	0.17	0.89	0.71	0.43	0.32	0.58	0.43
2	Kabini	Mysore	0.32	0.87	0.70	0.33	0.23	0.44	0.30
3	Suvarnavathy	Mysore	0.32	0.87	0.70	0.33	0.23	0.44	0.30
4	Shimsha	Banglore	0.30	0.71	0.56	0.25	0.16	0.33	0.21
		Hassan							
		Mysore							
5	Arkavathi	Banglore	0.20	0.41	0.33	0.13	0.08	0.17	0.10
6	Middle	Mysore	0.33	0.87	0.70	0.32	0.22	0.43	0.30
7	Palar	Mysore	0.32	0.87	0.70	0.33	0.23	0.44	0.30
8	Chinnar	salem	0.35	0.89	0.71	0.32	0.22	0.43	0.29
9	Bhavani	Coimbatore	0.79	1.69	1.35	0.54	0.34	0.72	0.45
10	Noyil	Coimbatore	0.49	1.01	0.81	0.31	0.19	0.42	0.26
11	Amravathi	Coimbatore	0.49	1.01	0.81	0.31	0.19	0.42	0.26
12	Thirumani-muthar	Tiruchchi-rappalli	0.40	0.94	0.75	0.32	0.21	0.43	0.28
13	Ponnaniar	-do-	0.38	1.01	0.81	0.38	0.26	0.50	0.34
14	Upper Coleron		0.43	1.34	1.07	0.55	0.38	0.73	0.51
15	Lower Coleron	NA							
16	C.Delta	NA							
		Total	**5.29**	**13.38**	**10.71**	**4.85**	**3.26**	**6.48**	**4.33**
		Avg.	**0.38**	**0.96**	**0.77**	**0.35**	**0.23**	**0.46**	**0.31**
		%age				**36.28**	**30.44**	**48.43**	**40.43**

Vaigai Basin

S. No.	Sub-Basin	Station	Average NIR (m)	Average GIR SW (m)	Average GIR GW (m)	Return Flow 0.6 (GIR - NIR) SW (m)	Return Flow 0.6 (GIR - NIR) GW (m)	Return Flow 0.8 (GIR - NIR) SW (m)	Return Flow 0.8 (GIR - NIR) GW (m)
1	Vaigai	Madurai	0.303	0.89	0.71	0.35	0.24	0.47	0.33
		Total	**0.30**	**0.89**	**0.71**	**0.35**	**0.24**	**0.47**	**0.33**
		Avg.	**0.30**	**0.89**	**0.71**	**0.35**	**0.24**	**0.47**	**0.33**
		%age.				**39.57**	**34.39**	**52.76**	**45.86**

Water Balance of Mahanadi Basin

	A	B	C	D	E	F	G	H
1								
2			Return Flow					
3			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
4			**SW**	**GW**	**Total**	**SW**	**GW**	**Total**
5	**A**	**Salient Features**						
6	(i)	Geographical Area (Mha)			14.159			14.159
7	(ii)	Culturable Area (Mha)			8.371			8.371
8	(iii)	Net Sown Area (Mha)			6.804			6.804
9	(iv)	Gross Sown Area (Mha)			8.430			8.430
10	(v)	Present Irrigation (Mha)			2.020			2.020
11	(vi)	Proposed Gross Sown Area (Mha)			10.882			10.882
12	(vii)	Population -Total (Million)			49.91			49.91
13		(a) Urban (Million)			30.65			30.65
14		(b) Rural (Million)			19.26			19.26
15	(viii)	Average NIR	0.167	0.167		0.167	0.167	
16	(ix)	Average GIR	0.671	0.537		0.671	0.537	
17								
18								
19	**B**	**Water Availability**						
20	(i)	Mean Annual Flow (Mm^3)	66880		66880	66880		66880
21	(ii)	75% dependable flow (Mm^3)	53780		53780	53780		53780
22	(iii)	Utilisable Flow SW (Mm^3)	50000		50000	50000		50000
23	(iv)	Total Replenishable GW (Mm^3)		16500	16500		16500	16500
24	(v)	Return Flow from Existing Irrigation (Mm^3)		2854	2854		2854	2854
25	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		11000	11000		11000	11000
26	(vii)	Total utilisable water (Mm^3)	50000	11000	61000	50000	11000	61000
27								
28		**Imports 4486**						
29		**Exports 5535**	-1049		-1049	-1049		-1049
30	**C**	**Gross Water Demand (Mm^3)**	**SW**	**GW**		**SW**	**GW**	
31	(i)	Domestic	2039	1476	3516	2039	1476	3516
32	(ii)	Industrial	2114	906	3019	2114	906	3019
33	(iii)	Energy	2084	521	2605	2084	521	2605
34	(iv)	Environmental releases and for Navigation	1000		1000	1000		1000
35	(v)	Lake/Reservoir Evaporation	4970		4970	4970		4970
36	(vi)	Gross non-agricultural demand	12207	2903	15110	12207	2903	15110
37								
38	**D.**	**Irrigation Water Requirement**						
39		**Case I Proposed Irrigation Area (59.1% of GSA)**			6.43			6.43
40	(i)	GIR (m)	0.67	0.54		0.67	0.54	
41	(ii)	Area to be irrigated (M ha)	2.93	3.50	6.43	2.50	3.93	6.43
42	(iii)	Water Demand (Mm^3)	19631	18900	38531	16750	21222	37972
43	(iv)	Total Gross Demand (Mm^3)	31838	21803	53641	28957	24125	53082
44								
45	**E.**	**Return Flow to the System (Mm^3)**						
46	(i)	50% of Domestic (85% to SW and 15% to GW)	1494	264	1758	1494	264	1758
47	(ii)	50 % of Industrial (All to SW)	1510	0	1510	1510	0	1510
48	(iii)	Energy	0	0	0	0	0	0
49	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.451	0.413		0.601	0.551	
50	(v)	Irrigation (90% of Return Flow to GW)	1666	14993	16659	2176	19584	21760
51	(vi)	Total return flow to the system	4670	15257	19927	5180	19848	25029
52								
53								
54	**F.**	**Balance (Mm^3)**						
55	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	30517	1600	32118	33909	3869	37778
56		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
57	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	17417	1600	19018	20809	3869	24678
58		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
59	(iii)	Total Utilisable Water {B (vii)} - Total Gross Demand {D (iv)}	21783	1600	23384	25175	3869	29044
60		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
61								

Water Balance of Mahanadi Basin

	A	B	C	D	E	F	G	H
62		**Case - II Proposed Irrigation (70% of GSA)**			7.62			7.62
63	(i)	Water depth (m)	0.67	0.54		0.67	0.54	
64	(ii)	Area to be irrigated (M ha)	3.62	4.00	7.62	3.62	4.00	7.62
65	(iii)	Water Demand (Mm^3)	24254	21600	45854	24254	21600	45854
66	(iv)	Total Gross Demand (Mm^3)	36461	24503	60964	36461	24503	60964
67								
68	G.	**Return Flow to the System (Mm^3)**						
69	(i)	50% of Domestic (85% to SW and 15% to GW)	1494	264	1758	1494	264	1758
70	(ii)	50 % of Industrial (All to SW)	1510	0	1510	1510	0	1510
71	(iii)	Energy	0	0	0	0	0	0
72	(iv)	Irrigation Return Flow Ratio	0.451	0.413		0.601	0.551	
73	(v)	Irrigation (90% of Return Flow to GW)	1986	17873	19859	2648	23830	26478
74	(vi)	Total return flow to the system	4990	18138	23128	5652	24095	29747
75								
76	H.	**Balance (Mm^3)**						
77	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	26214	1780	27995	26876	7737	34614
78		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
79	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	13114	1780	14895	13776	7737	21514
80		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
81	(iii)	Total Utilisable Water {B (vii)} - Total Gross Demand {D (iv)} +	17480	1780	19261	18142	7737	25880
82		Return Flow {E (vi)} - Existing Return Flow {B (v)}						

Water Balance of Godavari Basin

	A	B	C	D	E	F	G	H
1								
2								
3			Return Flow					
4			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
			SW	GW	Total	SW	GW	Total
5	A	**Salient Features**						
6	(i)	Geographical Area (Mha)			31.281			31.281
7	(ii)	Culturable Area (Mha)			18.041			18.041
8	(iii)	Net Sown Area (Mha)			14.357			14.357
9	(iv)	Gross Sown Area (Mha)			15.793			15.793
10	(v)	Present Irrigation (Mha)			4.12			4.12
11	(vi)	Proposed Gross Sown Area (Mha)			23.453			23.453
12	(vii)	Population -Total (Million)			101.32			101.32
13		(a) Urban (Million)			62.23			62.23
14		(b) Rural (Million)			39.09			39.09
15	(viii	Average NIR	0.20	0.20		0.20	0.20	
16	(ix)	Average GIR	0.56	0.45		0.56	0.45	
17								
18								
19	B	**Water Availability**						
20	(i)	Mean Annual Flow (Mm^3)	110540		110540	110540		110540
21	(ii)	75% dependable flow (Mm^3)	80550		80550	80550		80550
22	(iii)	Utilisable Flow SW (Mm^3)	76300		76300	76300		76300
23	(iv)	Total Replenishable GW (Mm^3)		40600	40600		40600	40600
24	(v)	Return Flow from Existing Irrigation (Mm^3)		6383	6383		6383	6383
25	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		27067	27067		27067	27067
26	(vii)	Total utilisable water (Mm^3)	76300	27067	103367	76300	27067	103367
27								
28		**Imports**						
29		**Exports 17359**	-17359		-17359	-17359		-17359
30	C	**Gross Water Demand (Mm^3)**						
31	(i)	Domestic	4140	2997	7137	4140	2997	7137
32	(ii)	Industrial	4509	1933	6442	4509	1933	6442
33	(iii)	Energy	4446	1112	5558	4446	1112	5558
34	(iv)	Environmental releases and for Navigation	2000		2000	2000		2000
35	(v)	Lake/Reservoir Evaporation	7690		7690	7690		7690
36	(vi)	Gross non-agricultural demand	22786	6041	28827	22786	6041	28827
37								
38	D.	**Irrigation Water Requirement**						
39		**Case I Proposed Irrigation Area (40.9% of GSA)**			9.604			9.604
40	(i)	GIR (m)	0.56	0.45		0.56	0.45	
41	(ii)	Area to be irrigated (M ha)	4.10	5.50	9.604	4.10	5.50	9.604
42	(iii)	Water Demand (Mm^3)	22982	24750	47732	22982	24750	47732
43	(iv)	Total Gross Demand (Mm^3)	45768	30791	76559	45768	30791	76559
44								
45	E.	**Return Flow to the System (Mm^3)**						
46	(i)	50% of Domestic (85% to SW and 15% to GW)	3033	535	3569	3033	535	3569
47	(ii)	50 % of Industrial (All to SW)	3221	0	3221	3221	0	3221
48	(iii)	Energy	0	0	0	0	0	0
49	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.386	0.333		0.514	0.444	
50	(v)	Irrigation (90% of Return Flow to GW)	1711	15402	17113	2280	20522	22802
51	(vi)	Total return flow to the system	7966	15937	23903	8535	21057	29592
52								
53								
54	F.	**Balance (Mm^3)**						
55	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	34695	5830	40525	35264	10950	46214
56		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
57	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	4705	5830	10535	5274	10950	16224
58		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
59	(iii)	Total Utilisable Water {B (vii)} - Total Gross Demand {D (iv)} +	21139	5830	26969	21708	10950	32658
60		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
61								

Water Balance of Godavari Basin

	A	B	C	D	E	F	G	H
62		**Case - II Proposed Irrigation (60% of GSA)**			14.072			14.072
63	(i)	GIR (m)	0.56	0.45		0.56	0.45	
64	(ii)	Area to be irrigated (M ha)	6.00	8.07	14.072	6.00	8.07	14.072
65	(iii)	Water Demand (Mm^3)	33611	36315	69926	33611	36315	69926
66	(iv)	Total Gross Demand (Mm^3)	56397	42356	98753	56397	42356	98753
67								
68	G.	**Return Flow to the System (Mm^3)**						
69	(i)	50% of Domestic (85% to SW and 15% to GW)	3033	535	3569	3033	535	3569
70	(ii)	50 % of Industrial (All to SW)	3221	0	3221	3221	0	3221
71	(iii)	Energy	0	0	0	0	0	0
72	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.386	0.333		0.514	0.444	
73	(v)	Irrigation (90% of Return Flow to GW)	2507	22560	25067	1728	30060	31788
74	(vi)	Total return flow to the system	8761	23096	31857	7982	30596	38578
75								
76	H.	**Balance (Mm^3)**						
77	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	24862	1423	26285	24083	8923	33006
78		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
79	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	-5128	1423	-3705	-5907	8923	3016
80		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
81	(iii)	Total Utilisable Water {B (vii)} - Total Gross Demand {D (iv)} +	11306	1423	12729	10527	8923	19450
82		Return Flow {E (vi)} - Existing Return Flow {B (v)}						

Annexure - 7.2

Water Balance of Godavari at Inchampalli

	A	B	C	D	E	F	G	H
1								
2								
3			Return Flow					
4			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
5	A	**Salient Features**	SW	GW	Total	SW	GW	Total
6	(i)	Geographical Area (Mha)			17.725			17.725
7	(ii)	Culturable Area (Mha)			9.243			9.243
8	(iii)	Net Sown Area (Mha)			7.468			7.468
9	(iv)	Gross Sown Area (Mha)			8.088			8.088
10	(v)	Present Irrigation (Mha)			1.132			1.132
11	(vi)	Proposed Gross Sown Area (Mha)			12.016			12.016
12	(vii)	Population -Total (Million)			56.20			56.20
13		(a) Urban (Million)			34.30			34.30
14		(b) Rural (Million)			21.90			21.90
15	(viii	Average NIR	0.20	0.20		0.20	0.20	
16	(ix)	Average GIR	0.56	0.45		0.56	0.45	
17								
18								
19	B	**Water Availability**						
20	(i)	Mean Annual Flow (Mm^3)	76185		76185	76185		76185
21	(ii)	75% dependable flow (Mm^3)	66193		66193	66193		66193
22	(iii)	Utilisable Flow SW (Mm^3)	53250		53250	53250		53250
23	(iv)	Total Replenishable GW (Mm^3)		23000	23000		23000	23000
24	(v)	Return Flow from Existing Irrigation (Mm^3)		3617	3617		3617	3617
25	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		15333	15333		15333	15333
26	(vii)	Total utilisable water (Mm^3)	53250	15333	68583	53250	15333	68583
27								
28		Imports 4540						
29		Exports 5290	-750		-750	-750		-750
30	C	**Gross Water Demand (Mm^3)**						
31	(i)	Domestic	2288	1666	3953	2288	1666	3953
32	(ii)	Industrial	2533	1086	3619	2533	1086	3619
33	(iii)	Energy	2498	625	3123	2498	625	3123
34	(iv)	Environmental releases and for Navigation	762		762	762		762
35	(v)	Lake/Reservoir Evaporation	3480		3480	3480		3480
36	(vi)	Gross non-agricultural demand	11561	3376	14937	11561	3376	14937
37								
38	D.	**Irrigation Water Requirement**						
39		**Case I Proposed Irrigation Area (47.1% of GSA)**			5.665			5.665
40	(i)	GIR (m)	0.56	0.45		0.56	0.45	
41	(ii)	Area to be irrigated (M ha)	2.00	3.665	5.665	2.00	3.665	5.665
42	(iii)	Water Demand (Mm^3)	11200	16493	27693	11200	16493	27693
43	(iv)	Total Gross Demand (Mm^3)	22761	19868	42630	22761	19868	42630
44								
45	E.	**Return Flow to the System (Mm^3)**						
46	(i)	50% of Domestic (85% to SW and 15% to GW)	1680	296	1977	1680	296	1977
47	(ii)	50 % of Industrial (All to SW)	1810	0	1810	1810	0	1810
48	(iii)	Energy	0	0	0	0	0	0
49	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.386	0.333		0.514	0.444	
50	(v)	Irrigation (90% of Return Flow to GW)	982	8834	9815	1308	11772	13079
51	(vi)	Total return flow to the system	4472	9131	13602	4798	12068	16867
52								
53								
54	F.	**Balance (Mm^3)**						
55	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	45429	979	46408	45756	3917	49672
56		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
57	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	35437	979	36416	35764	3917	39680
58		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
59	(iii)	Total Utilisable Water {B (vii)} - Total Gross Demand {D (iv)} +	34210	979	35189	34537	3917	38454
60		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
61								

Water Balance of Godavari at Inchampalli

	A	B	C	D	E	F	G	H
62		**Case - II Proposed Irrigation (60% of GSA)**			7.210			7.210
63	(i)	GIR (m)	0.56	0.45		0.67	0.54	
64	(ii)	Area to be irrigated (M ha)	3.00	4.21	7.210	3.00	4.21	7.210
65	(iii)	Water Demand (Mm^3)	16800	18945	35745	20100	22734	42834
66	(iv)	Total Gross Demand (Mm^3)	28361	22321	50682	31661	26110	57771
67								
68	G.	**Return Flow to the System (Mm^3)**						
69	(i)	50% of Domestic (85% to SW and 15% to GW)	1680	296	1977	1680	296	1977
70	(ii)	50 % of Industrial (All to SW)	1810	0	1810	1810	0	1810
71	(iii)	Energy	0	0	0	0	0	0
72	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.386	0.333		0.514	0.444	
73	(v)	Irrigation (90% of Return Flow to GW)	1279	11514	12793	2043	18383	20425
74	(vi)	Total return flow to the system	4769	11811	16580	5533	18680	24212
75								
76	H.	**Balance (Mm^3)**						
77	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	40127	1207	41333	37590	4286	41876
78		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
79	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	30135	1207	31341	27598	4286	31884
80		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
81	(iii)	Total Utilisable Water {B (vii)} - Total Gross Demand {D (iv)} +	28908	1207	30115	26372	4286	30658
82		Return Flow {E (vi)} - Existing Return Flow {B (v)}						

Water Balance of Krishna Basin

	A	B	C	D	E	F	G	H
1								
2			Return Flow					
3			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
4			SW	GW	Total	SW	GW	Total
5	A	**Salient Features**						
6	(i)	Geographical Area (Mha)			25.708			25.708
7	(ii)	Culturable Area (Mha)			19.294			19.294
8	(iii)	Net Sown Area (Mha)			15.326			15.326
9	(iv)	Gross Sown Area (Mha)			16.641			16.641
10	(v)	Present Irrigation (Mha)			3.88			3.88
11	(vi)	Proposed Gross Sown Area (Mha)			25.082			25.082
12	(vii)	Population -Total (Million)			114.08			114.08
13		(a) Urban (Million)			70.06			70.06
14		(b) Rural (Million)			44.02			44.02
15	(viii)	Average NIR	0.25	0.25		0.25	0.25	
16	(ix)	Average GIR	0.60	0.48		0.60	0.48	
17								
18								
19	B	**Water Availability**						
20	(i)	Mean Annual Flow (Mm^3)	69810		69810	69810		69810
21	(ii)	75% dependable flow (Mm^3)	60140		60140	60140		60140
22	(iii)	Utilisable Flow SW (Mm^3)	58000		58000	58000		58000
23	(iv)	Total Replenishable GW (Mm^3)		26400	26400		26400	26400
24	(v)	Return Flow from Existing Irrigation (Mm^3)		5598	5598		5598	5598
25	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		17600	17600		17600	17600
26	(vii)	Total utilisable water (Mm^3)	58000	17600	75600	58000	17600	75600
27								
28		**Imports 6810**						
29		**Exports 15100**	-8290		-8290	-8290		-8290
30	C	**Gross Water Demand (Mm^3)**						
31	(i)	Domestic	4661	3375	8036	4661	3375	8036
32	(ii)	Industrial	4258	1825	6082	4258	1825	6082
33	(iii)	Energy	4198	1050	5248	4198	1050	5248
34	(iv)	Environmental releases and for Navigation	2000		2000	2000		2000
35	(v)	Lake/Reservoir Evaporation	8480		8480	8480		8480
36	(vi)	Gross non-agricultural demand	23597	6249	29846	23597	6249	29846
37								
38	D.	**Irrigation Water Requirement**						
39		**Case I Proposed Irrigation Area (30.0% of GSA)**			7.53			7.53
40	(i)	GIR (m)	0.60	0.48		0.60	0.48	
41	(ii)	Area to be irrigated (M ha)	4.03	3.50	7.53	4.03	3.50	7.53
42	(iii)	Water Demand (Mm^3)	24180	16800	40980	24180	16800	40980
43	(iv)	Total Gross Demand (Mm^3)	47777	23049	70826	47777	23049	70826
44								
45	E.	**Return Flow to the System (Mm^3)**						
46	(i)	50% of Domestic (85% to SW and 15% to GW)	3415	603	4018	3415	603	4018
47	(ii)	50 % of Industrial (All to SW)	3041	0	3041	3041	0	3041
48	(iii)	Energy	0	0	0	0	0	0
49	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.350	0.288		0.467	0.383	
50	(v)	Irrigation (90% of Return Flow to GW)	1330	11971	13301	1773	15954	17726
51	(vi)	Total return flow to the system	7787	12574	20361	8230	16557	24786
52								
53								
54	F.	**Balance (Mm^3)**						
55	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	9528	1527	11055	9970	5510	15480
56		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
57	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	-142	1527	1385	300	5510	5810
58		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
59								
60								
61								

Water Balance of Krishna Basin

	A	B	C	D	E	F	G	H
					11.29			11.29
62		**Case - II Proposed Irrigation (45% of GSA)**	0.60	0.48		0.60	0.48	
63	(i)	GIR (m)	6.21	5.08	11.29	5.20	6.09	11.29
64	(ii)	Area to be irrigated (M ha)	37260	24384	61644	31200	29232	60432
65	(iii)	Water Demand (Mm^3)	60857	30633	91490	54797	35481	90278
66	(iv)	Total Gross Demand (Mm^3)						
67								
68	G.	**Return Flow to the System (Mm^3)**	3415	603	4018	3415	603	4018
69	(i)	50% of Domestic (85% to SW and 15% to GW)	3041	0	3041	3041	0	3041
70	(ii)	50 % of Industrial (All to SW)	0	0	0	0	0	0
71	(iii)	Energy	0.350	0.288		0.467	0.383	
72	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	2006	18057	20064	2577	23190	25766
73	(v)	Irrigation (90% of Return Flow to GW)	8463	18660	27123	9034	23793	32826
74	(vi)	Total return flow to the system						
75								
76	H.	**Balance (Mm^3)**	-2876	29	-2847	3754	314	4068
77	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +						
78		Return Flow {E (vi)} - Existing Return Flow {B (v)}	-12546	29	-12517	-5916	314	-5602
79	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +						
80		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
81								
82	*	Exceed mean Annual flow, hence not considered						
83	Note	Surface Water availability figures will be reduced due to increased retrun flow by about 6%.						
84		Taking this into account, the balance will be reduced by about 4200 Mm^3 in case of mean flow						
85		and by 3600 Mm^3 for 75% dependable flow.						

Water Balance of Pennar Basin

	A	B	C	D	E	F	G	H
1								
2			Return Flow					
3			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
4			SW	GW	Total	SW	GW	Total
5	A	**Salient Features**						
6	(i)	Geographical Area (Mha)			5.52			5.521
7	(ii)	Culturable Area (Mha)			3.04			3.035
8	(iii)	Net Sown Area (Mha)			1.97			1.966
9	(iv)	Gross Sown Area (Mha)			2.06			2.058
10	(v)	Present Irrigation (Mha)			0.99			0.99
11	(vi)	Proposed Gross Sown Area (Mha)			3.64			3.642
12	(vii)	Population -Total (Million)			18.20			18.2
13		(a) Urban (Million)			11.18			11.18
14		(b) Rural (Million)			7.02			7.02
15	(viii)	Average NIR	0.29	0.29		0.29	0.29	
16	(ix)	Average GIR	0.75	0.60		0.75	0.60	
17								
18								
19	B	**Water Availability**						
20	(i)	Mean Annual Flow (Mm^3)	6320		6320	6320		6320
21	(ii)	75% dependable flow (Mm^3)	4390		4390	4390		4390
22	(iii)	Utilisable Flow SW (Mm^3)	6860		6860	6860		6860
23	(iv)	Total Replenishable GW (Mm^3)		4930	4930		4930	4930
24	(v)	Return Flow from Existing Irrigation (Mm^3)		891	891		891	891
25	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		3287	3287		3287	3287
26	(vii)	Total utilisable water (Mm^3)	6860	3287	10147	53250	3287	56537
27								
28		**Imports 3388**						
29		**Exports 495**	2893		2893	2893		2893
30	C	**Gross Water Demand (Mm^3)**						
31	(i)	Domestic	744	538	1282	744	538	1282
32	(ii)	Industrial	802	344	1145	802	344	1145
33	(iii)	Energy	790	198	988	790	198	988
34	(iv)	Environmental releases and for Navigation	500		500	500		500
35	(v)	Lake/Reservoir Evaporation	500		500	500		500
36	(vi)	Gross non-agricultural demand	3336	1079	4415	3336	1079	4415
37								
38	D.	**Irrigation Water Requirement**						
39		**Case I Proposed Irrigation Area (30% of GSA)**			1.09			1.093
40	(i)	GIR (m)	0.75	0.60		0.75	0.60	
41	(ii)	Area to be irrigated (M ha)	0.39	0.70	1.09	0.39	0.70	1.093
42	(iii)	Water Demand (Mm^3)	2948	4200	7148	2948	4200	7148
43	(iv)	Total Gross Demand (Mm^3)	6283	5279	11563	6283	5279	11563
44								
45	E.	**Return Flow to the System (Mm^3)**						
46	(i)	50% of Domestic (85% to SW and 15% to GW)	545	96	641	545	96	641
47	(ii)	50 % of Industrial (All to SW)	573	0	573	573	0	573
48	(iii)	Energy	0.00	0.00	0.00	0.00	0.00	0
49	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.37	0.31		0.49	0.41	
50	(v)	Irrigation (90% of Return Flow to GW)	239	2148	2387	318	2864	3182
51	(vi)	Total return flow to the system	1356	2244	3601	1436	2960	4396
52								
53								
54	F.	**Balance (Mm^3)**						
55	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	1891	-639	1251	1970	76	2047
56		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
57	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)}	-39	-639	-679	40	76	117
58		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
59								
60								
61								

Water Balance of Pennar Basin

	A	B	C	D	E	F	G	H
62		**Case - II Proposed Irrigation (37% of GSA)**			1.350			1.350
63	(i)	GIR (m)	0.75	0.60		0.75	0.60	
64	(ii)	Area to be irrigated (M ha)	0.650	0.700	1.350	0.650	0.700	1.350
65	(iii)	Water Demand (Mm^3)	4875	4200	9075	4875	4200	9075
66	(iv)	Total Gross Demand (Mm^3)	8211	5279	13490	8211	5279	13490
67								
68	G.	**Return Flow to the System (Mm^3)**						
69	(i)	50% of Domestic (85% to SW and 15% to GW)	545	96	641	545	96	641
70	(ii)	50 % of Industrial (All to SW)	573	0	573	573	0	573
71	(iii)	Energy	0	0	0	0	0	0
72	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.37	0.31		0.49	0.41	
73	(v)	Irrigation (90% of Return Flow to GW)	310	2786	3096	413	3715	4128
74	(vi)	Total return flow to the system	1428	2883	4311	1531	3812	5343
75								
76	H.	**Balance (Mm^3)**						
77	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	34	-1	33	137	928	1066
78		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
79	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	-1896	-1	-1897	-1793	928	-864
80		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
81								
82	*	Exceed mean Annual flow, hence not considered						
83	Note	Surface Water availability figures will be reduced due to increased retrun flow by about 11%.						
84		Taking this into account, the balance will be reduced by about 700 Mm^3 in case of mean flow						
85		and by 480 Mm^3 for 75% dependable flow.						

Water Balance of Cauvery Basin

	A	B	C	D	E	F	G	H
1			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
2			SW	GW	Total	SW	GW	Total
3	A	**Salient Features**						
4	(i)	Geographical Area (Mha)			8.116			8.116
5	(ii)	Culturable Area (Mha)			5.224			5.224
6	(iii)	Net Sown Area (Mha)			3.878			3.878
7	(iv)	Gross Sown Area (Mha)			4.576			4.576
8	(v)	Present Irrigation (Mha)			1.92			1.92
9	(vi)	Proposed Gross Sown Area (Mha)			6.791			6.791
10	(vii)	Population -Total (Million)			54.98			54.98
11		(a) Urban (Million)			33.77			33.77
12		(b) Rural (Million)			21.21			21.21
13	(viii)	Average NIR	0.38	0.38		0.38	0.38	
14	(ix)	Average GIR	0.96	0.77		0.96	0.77	
15								
16								
17	B	**Water Availability**						
18	(i)	Mean Annual Flow (Mm^3)	21360		21360	21360		21360
19	(ii)	75% dependable flow (Mm^3)	19370		19370	19370		19370
20	(iii)	Utilisable Flow SW (Mm^3)	19000		19000	19000		19000
21	(iv)	Total Replenishable GW (Mm^3)		12300	12300		12300	12300
22	(v)	Return Flow from Existing Irrigation (Mm^3)		891	891		891	891
23	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		8200	8200		8200	8200
24	(vii)	Total utilisable water (Mm^3)	19000	8200	27200	53250	8200	61450
25								
26		Imports 744						
27		Exports 2136	-1392		-1392	-1392		-1392
28	C	**Gross Water Demand (Mm^3)**						
29	(i)	Domestic	2247	1626	3873	2247	1626	3873
30	(ii)	Industrial	1684	722	2405	1684	722	2405
31	(iii)	Energy	1660	415	2075	1660	415	2075
32	(iv)	Environmental releases and for Navigation	2000		2000	2000		2000
33	(v)	Lake/Reservoir Evaporation	1630		1630	1630		1630
34	(vi)	Gross non-agricultural demand	9221	2763	11984	9221	2763	11984
35								
36	D.	**Irrigation Water Requirement**						
37		**Proposed Irrigation Area (40% of GSA)**			2.717			2.717
38	(i)	GIR (m)	0.96	0.77		0.96	0.77	
39	(ii)	Area to be irrigated (M ha)	1.12	1.60	2.717	1.12	1.60	2.717
40	(iii)	Water Demand (Mm^3)	10723	12320	23043	10723	12320	23043
41	(iv)	Total Gross Demand (Mm^3)	19944	15083	35027	19944	15083	35027
42	E.	**Return Flow to the System (Mm^3)**						
43	(i)	50% of Domestic (85% to SW and 15% to GW)	1646	290	1936	1646	290	1936
44	(ii)	50 % of Industrial (All to SW)	1203	0	1203	1203	0	1203
45	(iii)	Energy	0	0	0	0	0	0
46	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.363	0.304		0.483	0.405	
47	(v)	Irrigation (90% of Return Flow to GW)	764	6874	7638	1017	9152	10169
48	(vi)	Total return flow to the system	3613	7165	10778	3866	9443	13309
49	F.	**Balance (Mm^3)**						
50	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	-3672	-609	-4281	-3419	1669	-1750
51		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
52	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	-5662	1	11	-5409	1669	-3740
53		Return Flow {E (vi)} - Existing Return Flow {B (v)}						

* Exceed mean Annual flow, hence not considered

Note : Surface Water availability figures will be reduced due to increased retrun flow by about 30%. Taking this inot account, the balance will be reduced by about 6400 Mm^3 in case of mean flow and by 5800 Mm^3 for 75% dependable flow.

Annexure - 7.2

Water Balance of Vaigai Basin

	A	B	C	D	E	F	G	H
1								
2			Return Flow					
3			0.6 (GIR - NIR)			0.8 (GIR - NIR)		
4			SW	GW	Total	SW	GW	Total
5	A	**Salient Features**						
6	(i)	Geographical Area (Mha)			0.774			0.774
7	(ii)	Culturable Area (Mha)			0.478			0.478
8	(iii)	Net Sown Area (Mha)			0.318			0.318
9	(iv)	Gross Sown Area (Mha)			0.387			0.387
10	(v)	Present Irrigation (Mha)			0.108			0.108
11	(vi)	Proposed Gross Sown Area (Mha)			0.574			0.574
12	(vii)	Population -Total (Million)			5.465			5.465
13		(a) Urban (Million)			3.334			3.334
14		(b) Rural (Million)			2.131			2.131
15	(viii	Average NIR	0.303	0.303		0.303	0.303	
16	(ix)	Average GIR	0.890	0.710		0.890	0.710	
17								
18								
19	B	**Water Availability**						
20	(i)	Mean Annual Flow (Mm^3)	670		670	670		670
21	(ii)	75% dependable flow (Mm^3)	505		505	505		505
22	(iii)	Utilisable Flow SW (Mm^3)	505		505	505		505
23	(iv)	Total Replenishable GW (Mm^3)		1095	1095		1095	1095
24	(v)	Return Flow from Existing Irrigation (Mm^3)						
25	(vi)	Utilisable GW (2/3 of iv) (Mm^3)		730	730		730	730
26	(vii)	Total utilisable water (Mm^3)	505	730	1235	505	730	1235
27								
28		Imports 601						
29		Exports 260	341		341	341		341
30	C	**Gross Water Demand (Mm^3)**						
31	(i)	Domestic	222	162	384	222	162	384
32	(ii)	Industrial	165	71	235	165	71	235
33	(iii)	Energy	162	41	203	162	41	203
34	(iv)	Environmental releases and for Navigation	7		7	7		7
35	(v)	Lake/Reservoir Evaporation	0		0	0		0
36	(vi)	Gross non-agricultural demand	556	273	829	556	273	829
37								
38	D.	**Irrigation Water Requirement**						
39		**Proposed Irrigation Area (30% of GSA)**			0.172			0.172
40	(i)	GIR (m)	0.89	0.71		0.89	0.71	
41	(ii)	Area to be irrigated (M ha)	0.047	0.125	0.172	0.047	0.125	0.172
42	(iii)	Water Demand (Mm^3)	418	888	1306	418	888	1306
43	(iv)	Total Gross Demand (Mm^3)	975	1161	2135	975	1161	2135
44								
45	E.	**Return Flow to the System (Mm^3)**						
46	(i)	50% of Domestic (85% to SW and 15% to GW)	163	29	192	163	29	192
47	(ii)	50 % of Industrial (All to SW)	118	0	118	118	0	118
48	(iii)	Energy	0	0	0	0	0	0
49	(iv)	Irrigation Return Flow Ratio (Table - 7.3)	0.398	0.346		0.530	0.462	
50	(v)	Irrigation (90% of Return Flow to GW)	47	426	474	63	569	632
51	(vi)	Total return flow to the system	329	455	784	345	598	942
52								
53								
54	F.	**Balance (Mm^3)**						
55	(i)	Mean Annual Flow {B (i)} - Total Gross Demand {D (iv)} +	-365	25	-340	-349	167	-182
56		Return Flow {E (vi)} - Existing Return Flow {B (v)}						
57	(ii)	75% dependable flow {B (ii)} - Total Gross Demand {D (iv)} +	-530	25	-505	-514	167	-347
58		Return Flow {E (vi)} - Existing Return Flow {B (v)}						

Annexure 8.1

Tamil Nadu Acts Relating to Irrigation Matter

I Acts Governing Irrigation Practices.

1. The Madras Compulsory Labour Act, 1858
2. Tamil Nadu Revenue Recovery Act, 1864
3. Tamil Nadu River Conservancy Act, 1884
4. Tamil Nadu Canals and Public Ferries Act, 1890
5. Tamil Nadu Land Encroachment Act, 1905
6. Madras Survey and Boundaries Act, 1923
7. The Periar Irrigation Tanks (Preservation) Act, 1934
8. Tamil Nadu Irrigation Works (Repairs, Improvement and Construction) Act, 1943
9. The Tamil Nadu Irrigation Tanks Improvement Act, 1949
10. Tamil Nadu Requisitioning and Acquisition of Immovable Property Act, 1956 as modified on 01/12/1973
11. Tamil Nadu Panchayats Act, 1958
12. Madras Irrigation Works (Construction of field bothies) Act, 1959
13. Tamil Nadu Water Supply and Drainage Board Act as amended 1971

II Acts Relating to Land Acquisition and Having a Bearing of Irrigation

14. Land Acquisition Act, 1884 as amended in 1923, 1948, 1953 and 1961

III Acts Relating to Irrigation Cess

15. Tamil Nadu Irrigation Cess Act, 1865
16. Tamil Nadu Land Revenue Assessment Act, 1875
17. Tamil Nadu Irrigation Cess (Amendment) Act, 1900
18. Tamil Nadu Land Revenue Assessment (Amendment) Act, 1914
19. Bhavani Reservoir Irrigation Cess At, 1933
20. Madras Irrigation Cess (Amendment), 1940
21. Tamil Nadu Irrigation Works (Repairs, Improvement and Construction) Act, 1943
22. The Tamil Nadu Irrigation Cess (Amendment) Act, 1945
23. Mettur Canals Irrigation Cess Act, 1953
24. Tamil Nadu Irrigation (Levy of Betterment Contribution) Act, 1955
25. Madras Additional Assessment and Additional Water Cess Act, 1963

Annexure – 8.2

THE HELSINKI DECLARATION

As adopted by the Meeting of the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes at Helsinki (Finland) on 4 July 1997

Following the entry into force of the Convention on the Protection and Use of Transboundary Water Courses and International Lakes (hereinafter referred to as the Convention) on 6 October 1996.

WE, THE PARTIES TO THE CONVENTION,

gathered at Helsinki, Finland, from 2 to 4 July 1997 on the occasion of our first meeting, have committed ourselves to its full implementation and further development. We see this Convention as a major instrument of international co-operation.

The problems that we are facing are not unique to transboundary waters. They should be seen in the context of integrated water management. Thus, our co-operation on transboundary waters will also help to improve the management of internal waters and ensure consistency in the protection and use of both internal and transboundary waters. We will apply, as appropriate, the principles of the Convention when drawing up, revising, implementing and enforcing our national laws and regulations on water.

Our co-operation will focus on five programme areas in our work plan : joint bodies, assistance to countries will economies in transition, integrated management of water and related ecosystems, land-based pollution control, water supply and human health.

We will ensure the protection and sustainable use of transboundary waters by co-operating closely at the regional, sub-regional, national, provincial and local levels. We will delegate relevant activities to the lowest appropriate level.

We encourage all ECE member countries to ratify the Convention, and all other countries to draw on its provisions when formulating and implementing their water policies. We encourage all ECE member countries to ratify under the umbrella of this Convention relevant conventions and agreements, such as the Convention on Co-operation for the Protection and Sustainable Use of the Danube River.

We call on ECE member countries which have not yet become Parties to base their co-operation relating to transboundary waters on bilateral and multilateral agreements consistent with the Convention. At their request, we will support them with advice in drawing up or adapting such agreements.

We invite the executive bodies or related conventions as well as relevant organisations and institutions to co-operate actively in our activities so that both sides can benefit from one another's experience. We call upon them to take into account the provisions of the Convention. We express our readiness to advise them on the implementation of their activities relevant to the Convention.

Broad public participation is essential for implementing and developing further the Convention. We support public involvement through the participation of representatives of major groups in activities under the Convention. We need an ECE-wide water partnership to foster the dialogue between representatives of Governments, public and private sector organisations, joint bodies established for the protection and sustainable use of transboundary inland waters and the marine environment, NGOs, the scientific community and all those involved in water management and environmental protection.

We encourage all ECE member countries to organise conferences, workshops, training courses and study tours for the implementation of the Convention, subject to the availability of human and financial resources.

We will implement the decision of the 1995 Sofia Ministerial Conference "Environment for Europe" relevant to transboundary waters. We will contribute to the preparations for the 1998 Aarhus Ministerial Conference and the 1999 London Ministerial Conference on Environment and Health and will consider our role in any follow-up.

By 1999, we aim to prepare jointly with the Regional Office for Europe of the World Health Organisation (WHO/EURO) an international instrument to address the problems of water-related diseases to be submitted for adoption at the 1999 London Ministerial Conference on Environment and Health.

We will promote the regional implementation of Agenda 21 by protecting water against pollution and unsustainable use in accordance with the results of the special session of the General Assembly (New York, June 1997). We offer to share our experience with other regions in the world.

We encourage countries with economies in transition which are riparian to the same transboundary waters to prepare and implement joint projects on human resources development and institutional capacity-building to resolve existing water-management problems and prevent future disputes over water resources. We will support the ECE Regional Advisory Service Programme in facilitating and implementation of such joint activities under the Convention. We call on financial institutions and funding mechanisms which carry our assistance projects (such as the World Bank, GEF, PHARE, Tacis and CREDO) to give high priority to such joint country initiatives when deciding on funding.

As a result of this co-operation, we are convinced that transboundary waters in this region will be used in a sustainable way to the benefit of all countries. We firmly believe that the conditions of these waters will improve, since we are committed to cutting pollution, improving the quality of aquatic ecosystems, protecting human health and safety, and making the best sustainable use of water.

We, the Parties, note with appreciation that at this meeting ECE member countries which have not yet become Parties have associated themselves with this declaration.

We welcome the offer of the Government of the Netherlands to host the second meeting of the Parties in the year 2000.

Annexure 8.3

BASIN APPROACH INITIATIVES IN INDIA

Damodar Valley Corporation

After the catastrophc flood of 1943, in order to suggest remedial measures, the Governor of Bengal appointed the "Damodar Flood Enquiry Committee" which suggested creation of an authority similar to that of Tennesee Valley Authority(TVA of United States). Mr. W.L. Voorduin, a senior engineer of TVA., prepared the preliminary memorandum embodying the outline of a plan designed for achieving flood control, irrigation, power generation and navigation. As a result of this, the Damodar Valley Corporation (DVC) came into existence on 7 July, 1948 for development and management of the basin as a whole. The functions of DVC include promotion and operation of irrigation, water supply, drainage, hydro-electric and thermal power generation, flood control, navigation, afforestation, control of soil erosion, public health, agricultural, industrial, economic and general well being in the Damodar Valley. The Corporation is headed by a Chairman with two members appointed by the Central Government. The Corporation have the powers to do anything which may be necessary or expedient for carrying out its functions.

The Damodar Valley Project as envisaged by Mr. Voorduin was a multi-purpose project to afford flood control, to generate 200 MW power and to provide irrigation facilities to about 0.308 Mha in West Bengal by constructing eight dams and a barrage. However, it was later decided to have only four dams, namely, Tilaiya, Konar, Maithon and Panchet and a barrage at Durgapur under the control of DVC. Subsequently, Tenughat dam has been constructed by the Government of Bihar mainly for industrial water supply. The flood absorption capacity of 1,867 MCM could only be created as against the originally planned figure of 3,580 MCM due to reduced scope of work. At present as against the broader scope envisaged originally for functioning of DVC, the irrigation has been handed over to the Government of West Bengal, the Tenughat Project operates outside the purview of DVC and the navigation has hardly taken off. DVC now continues to be in existence for the management and operation of all the projects under its control excluding water and power distribution to consumers. Thus, the functioning of DVC is almost similar to that of TVA of United States.

Krishna – Godavari Commission

The Krishna-Godavari Commission was constituted in 1961 in order to review the availability of supplies in Krishna and Godavari basins and to determine the extent to which further demands on these basins could be met on the basis of annual flows at Vijaywada on Krishna and Dowlaiswaram on Godavari and the other points taking into account upstream utilisation. The other terms of reference of the Commission also include :

a. Reporting on the requirements of the projects on the Krishna and Godavari –

1. in operation in 1951 ;
2. as approved by the Govt. of India for execution ;
3. included in the Plans but not yet approved by the Government of India ;
4. projects proposed by the States ; and
5. such minor schemes as may have been sanctioned upto March 1961.

b. Reporting on the feasibility of diverting any surplus supplies in the Godavari to the Krishna indicating the quantity to be diverted and the cost involved.

The Commission was wound up after submission of its final report in 1962. The recommendations of the Commission include establishment of a network of hydrometrological, sediment and water quality observation sites as well as setting up of inter-state river board for co-ordinated planning and integrated operation of all projects, etc.

Sone River Commission

The Sone River Commission was constituted in 1980. The scope of Commission was limited only to the extent of compiling and analysing hydrological and hydrometeorlogical data, consumptive use data and to carry out investigations and studies for the preparation of basin and regional plans for optimum use of Sone river waters for irrigation and multi-purpose uses, without any binding on the part of the States to accept the findings. The functions of the Commission were :

i. To compile and analyse hydrometeorlogical data of river Sone and its tributaries including assessment of yield according to different dependability at different points;
ii. To collect and compile all data of utillisation of Sone waters in the three States including data related to agronomic, geological and socio-economic aspects ;
iii. To collect and compile data in respect of projects completed, under construction, proposed, under consideration and under investigation including studies conducted by the State Govt. for further development :
iv. To undertake supplementary investigations and studies as necessary for preparing basin and regional plans for development of water and land resources; and
v. To prepare and present a comprehensive basin and regional plan for optimum use of Sone waters for irrigation and other multi-purposes uses taking into account possible use of Ganga Waters by lift.

The Commission prepared a comprehensive Sone river basin plan for optimum use of its water for various uses after carrying out system studies. The Sone River Commission has since been wound up in 1988 after submission of the final report containing the details of master plan for Sone basin.

Ganga Flood Control Board and Ganga Flood Control Commission

The Ganga Flood Control Board was set up in 1972 by a Government of India Resolution. As per clause 5 of the Resolution, it was decided that Government of India would set up the Ganga Flood Control Commission (GFCC) for attending to the specific works of Ganga basin and for assisting the Ganga Flood Control Board. Accordingly, the GFCC was constituted in April, 1972. The important functions assigned to this Commission are under :

i. to prepare a comprehensive Plan of flood control for the Ganga basin. The field investigation and collection of data for the purpose will be carried out by the State Governments.
ii. to draw out a phased and coordinated programme of implementation of works in the basinwise plans.
iii. To advise the concerned states to follow guidelines in respect of quality control, material specifications, and maintenance in order to ensure the implementation of works and the maintenance thereof to proper standards ;
iv. to prepare the annual programme for works and allocation of cost whenever required for consideration of the Board ;

v. to make an assessment of the existing waterways under the road and rail bridge and to determine additional waterways to be provided for reducing the drainage congestion to reasonable limits.
vi. to monitor the execution of the important flood control schemes particularly those receiving central assistance or being executed under the central sector :
vii. examination of flood control, drainage, anti-water logging and anti-erosion schemes of Ganga basin states except for the schemes of the States of Haryana, Uttar Pradesh, Delhi on the river Yamuna in the reach Tajewala to Okhla barrage.
viii. documentation and dissemination of findings of special studies.
ix. to evaluate the performance of major flood control measures executed by the States including all the inter-state flood control schemes.

The Commission is headed by a Chairman and two full time Members and part time Members from the states of Bihar, Uttar Pradesh, West Bengal, Madhya Pradesh, CWC, CWPRS, Ministry of Surface Transport, Railway Board and Chief engineers of all co-basin States of Haryana, Himachal Pradesh, Rajasthan and NCT of Delhi.

The problems of flood erosion and drainage of the States of Bihar, Haryana, Himachal Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh, West Bengal and NCT Delhi are dealt by GFCC. The administrative cost GFCC is borne by the Central Government but implementation of schemes is done by respective State Government within its jurisdiction.

So far, the GFCC has completed the master plans of 23 river systems of Ganga Sub-basin. These plans are being updated. A report on adequacy of waterways under the road and rail bridges of Rupnarayan-Haldia-Rasulpur river system has been completed. The Commission has also finalised the flood management schemes, namely Buxar-Koelwar embankment scheme, Tamluk drainage scheme and Ghea Kunti basin drainage scheme. In addition, the Commission has undertaken performance evaluation studies for various flood management schemes.

Brahmaputra Board

The Brahmaputra Board was set up in 1980 to prepare a master plan for the control of floods in the Brahmaputra valley giving due regard to the overall development and utilisation of the water resources of the valley for irrigation, hydropower, navigation and other beneficial purposes. The Board is a body corporate having perpetual succession. The Board is headed by a Chairman appointed by the Central Government and has one member each from the States of Assam, Meghalaya, Nagaland, Manipur, Tripura, Mizoram and Arunachal Pradesh apart from members from the Central Water Commission, Central Electricity Authority, Geological survey of India and India Meteorological Department. The main functions of the Board are :

1. Preparation of plan for flood control and utilisation of water resources for various uses;
2. Preparation of detailed reports and estimates for the proposed projects; and
3. Construction, maintenance and operation of multi-purpose projects with the approval of Central Government.

The Board has so far prepared Master Plan Part-I for main stem of river Brahmaputra, Part-II for the Barak sub-basin and Master Plan for nine tributaries of Brahmaputra river and six rivers of Tripura under the Master Plan Part-III. These master plans have been circulated to the Sates Governments Central Government and other concerned organisations. The works under progress include surveys and investigation for preparation of Master Plans in addition to survey and investigation of specific drainage schemes, multi-purpose projects viz. Pagladiya, Tipaimikh, Subansiri, Dihang, Lohit and Kulsi. The Board is also setting up North Eastern Hydraulic and Allied Research Institute at North Guwahati. It is proposed to take up the pre-construction work of Tipaimukh Dam and the construction of Pagladiya Dam project on receipt of investment clearance.

Narmada Control Authority

The Narmada Control Authority set up in 1980 is meant mainly for the limited purpose of overseeing, the implementation of the award of the Narmada Water Dispute Tribunal (1979) for planning and management of the river basin including storage apportionment, regulation and control of Narmada waters, sharing of power benefits from Sardar Sarovar Project, etc. The Authority is headed by Secretary, Union Ministry of Water Resources as Chairman and the Executive Member being the incharge of administrative working of the Authority. The funding of the Authority is from the States of Madhya Pradesh, Maharashtra, Gujarat and Rajasthan in equal share.

A Review Committee headed by the Union Minister of Water Resources and Chief Ministers of the States of Madhya Pradesh, Maharashtra, Gujarat and Rajasthan as members has to take final decision on matters of any disagreement in the Executive Committee. The decision of the Review Committee is final and binding on all co-basin States

Besides the activities of implementation of environmental safeguards and Rehabilitation and Resettlement activity in Sardar Sarovar Project, the Authority is engaged in preparation of reports for protection of 14 villages and 2 towns in Madhya Pradesh from the backwater effects of Sardar Sarovar Project. It is now implementing Phase-I of the scheme for setting up sophisticated hydromet network in Narmada basin.

Bhakara –Beas Management Board (BBMB)

Bhakara –Beas Management Board (BBMB) was constituted through an executive order in accordance with the Section 79 of the Punjab Reorganisation Act 1966 to regulate the supply of the river Sutlej, Ravi and Beas waters to the States of Punjab, Haryana, Rajasthan and NCT of Delhi and to distribute power form the Bhakra-Nangal and Beas Projects to the States of Punjab, Haryana, Himachal Pradesh, J&K, UT of Chandigarh and Delhi when required. The Board is headed by a Chairman appointed by the Central Govt. with members from the co-basin States, CWC, Central Ground Water Board, etc. the Board falls under the category of organisation responsible for the operation and maintenance of water resources projects.

The Board has been holding monthly meetings to take stock of the inflow conditions in the reservoirs and to allocate water for irrigation to the basin States from reservoirs at Bhakara and Pong. Distribution of power is also being decided by the Board in consultation with the beneficiary States.

Upper Yamuna River Board

Yamuna water dispute remained pending for several years over sharing of waters amongst the co-basin states. The dispute was resolved by signing a Memorandum of understanding (MOU) on 12th May 1994 by the Chief Ministers of the co-baisn states. The MOU provides annual allocation of 5.730 BCM to Haryana, 4.032 BCM to Uttar Pradesh, 1.119 BCM to Rajasthan, 0.378 BCM to Himachal Pradesh and 0.724 BCM to NCT of Delhi. The agreement takes care of the irrigation and consumptive drinking water needs of all co-basin states and has opened up possibilities of development of water resources in the Upper Yamuna River Basin. The Board has been constituted for the purpose of allocating the available flows among co-basin States within the overall framework of the agreement.

The MOU also provides that separate agreements will be executed in respect of each identified storage in the Upper Yamuna River Basin within the overall allocation made under the agreement.

The Board is headed by the Member, Water Planning and Projects, Central Water Commission as Chairman and has members from all the co-basin States of Haryana, Uttar Pradesh, Rajashtan, Himachal Pradesh and NCT of Delhi. The functions of the Board include i) Regulation and supply of water from all storages and barrages up to and including Okhla barrage ; ii) maintenance of minimum flow in a phased manner ; iii) monitoring of return flows from the water withdrawals by Delhi from Yamuna after allowing for the consumptive use for the municipal and drinking water purposes; iv) coordination for maintenance of water quality, conservation of water and smooth implementation of the inter-state projects. The funds requirements for the Board will be provided by all co-basin States in equal share.

The disagreement in Board meetings, if any, will be settled by the Upper Yamuna Review Committee headed by the Union Minister of Water Resources with Chief Ministers of all co-basin State as Members. The decision of the Review Committee is final and binding on all co-baisn States. The Board has been allocating the waters of river Yamuna up to Okhla to the co-basin States.

Other Organisations

Apart form the above, several other organisations like the Betwa River Board in charge of Rajghat dam across Betwa, the Bansagar Control Board in charge of Bansagar dam across Sone, the Mahi Control Board in charge of Mahi Bajajsagar project across Mahi and the Sardar Sarovar project across Narmada can be cited as examples of the river basin organisations set up mainly to achieve efficient , economic and early execution of important inter-state water resources development projects.

In addition to the above, studies for preparation of basin level plans have also been undertaken in the Central Water Commission (CWC). The erstwhile Ganga Brahmaputra Water Studies (GBWS) Organisation was created in 1987 in CWC with the overall objective to work out alternative strategies for development of vast resources of Ganga-Brahmaputra-Meghna basin for the benefit of the region. Subsequently, the objective was revised to confine the work to Ganga sub-basin only. The GBWS Organisation prepared a report "Ganga Basin – Water Resources Development – A Perspective Plan" in 1987. The report was circulated to the basin States. The CWC, with the UNDP assisted Systems Engineering Project, has also carried out comprehensive studies for the development of Mahanadi basin using system engineering techniques during 1982-87. The Basin Planning and Management Organization of the CWC has been coordinating the work of preparation of river basin master plans by the States and the Union Territories.

Incidentally, basin level planning has been attempted in various cases without, the limited purposes such as speedy implementation of water resources projects, overviewing the implementation of the awards of water dispute tribunals, preparation of river basin master plans for specific purposes and operation and maintenance of water resources projects except for Damodar Valley Corporation which was entrusted with the overall development of river basin.

GLOSSARY

Agreement: That part of the contract which formally binds the parties to fulfil their respective obligation.

Antifoamants: Chemicals added to detergents in order to keep the creation of foam to a minimum.

Aquaculture : The raising of plants and animals in the sea, a lake, a river, or other bodies of water.

Aquifer:A porous geological formation which can store an appreciable amount of ground water and from which water can be extracted in useful quantities.

Ash Pond : The water body created for discharging industrial effluents Especially in thermal power plants.

Backwater : A creek, arm of the sea or series of connected lagoons, usually parallel to the coast, separated from the sea by a narrow strip of land but communicating with it through barred outlets.

Bay : A large estuary with a relatively high degree of flushing.

Betterment Levy : A contribution from beneficiaries in kind or cash, constituting a portion of unearned income due to benefits that accrue to land, in an area on which the government has invested or proposes to invest for development of irrigation, flood protection or drainage scheme for purpose of reclamation. It is variously titled as 'inclusion fee', 'contribution', and 'capital levy'.

Biodiversity : Variety and variability of species in an ecosystem.

Biological Oxygen Demand (BOD) : The amount of dissolved oxygen required by the organisms and for the decomposition of organic matter in water.

Biomapping : The biological status of river water depicted on map.

Boundary River : The part of a river which constitutes the boundary between two states or countries.

Capacity Building : The process of building organisation, human resources and the legal and regulatory framework needed for effective and efficient water resources management.

Capital Cost: The total expenditure incurred on awork since the beginning of its construction, excluding cost of operation, maintenance and repairs, but including cost of investigations and of all extensions and improvements.

Catchment Area : The area from which runoffl flows into a river, reservoir, etc.

Check Dam : Small dam constructed in a gully or other small watercourse to decrease the stream flow velocity, minimize channel scour and promote deposition of sediment.

Chemical Oxygen Demand : A measure of the oxygen required to oxidize all the compounds in the water.

Chlorination : The use of chlorine for the treatment of water, sewage or industrial wastes for disinfection or oxidation.

Coliform : Pertaining to the bacilli commonly commensal in the intestines of humans and other vertebrates.

Combined Wastewater : A mixture of surface runoff and other wastewater such as domestic.

Community Development : The participation of the people themselves in efforts to improve their level of living with as much reliance as possible on their own initiative and the provision of technical and other services in ways which encourage initiative, self-help and mutual help and make these more effective.

Conjunctive Irrigation Planning : Planning an irrigation project in a given area having underground resources of water supply in addition to the overground, so that both the surface and subsurface water resources are so planned as to obtain the most economical and wise combination of the use of water from the two sources.

Conjunctive Use of Water: Use of surface and ground water conjunctively for irrigation, water supply, industry etc.

Conservation : The act of maintaining entire, of protecting, preserving and improving, with undertones of permanence and saving from waste (in quantity) and deterioration (in quality).

Consumptive Use : The quantity of water used by the vegetative growth of a given area in transpiration and that evaporated from the soil.

Contamination : To introduce a substance that would cause the concentration of that substance to exceed the maximum contaminant level and make the water unsuitable for its intended use.

Conversion : A resource recovery method that uses biological, chemical, or mechanical processes to transform solid waste materials into usable forms.

Cooling Pond : An artificial lake used for the natural cooling of condenser-cooling water serving a conventional power station.

Cost Recovery : Fee structure that covers the cost of providing the service or investment.

Creek : A notable physiographic feature of salt marshes, especially low marshes, in the development of tidal creeks in the marsh itself.

Culturable Command Area : This represents the culturable area in the gross command area .

Decentralization : The distribution of responsibilities for decision making and operations to lower levels of government, community organization, the private section and non-governmental organizations.

Dechlorination : The partial or complete reduction of residual chlorine in a liquid by any chemical or physical process.

Delta : It is the depth of Irrigation water.

Demand Management : Programme which is adopted to achieve effective management of use of water resources in order to meet the general objectives of economic efficiency, environmental conservation and community and consumer satisfaction.

Depreciation : The loss in service value of a projectdue to (i) wear and tear not covered by current repairs, (ii) obsolescence or inadequacy resulting from age, physical change, supersession by reasons of inventions, discoveries, changes in public demand or public requirement, or (iii) loss suffered through the destruction of property by extraordinary casualties.

Differential Water Rate : Rate of water taken on dry land for governmental sources of irrigation corresponding to the difference between the assessment on dry lands and wet lands.

Dilution : A form of effluent disposal in which relatively small volume of effluent is discharged into large receiving body of water.

Disease : A particular destructive process in an organism with a specific cause and characteristic symptoms.

Dissolved Oxygen (DO) : The amount of gaseous Oxygen dissolved in water and available for chemical activity.

Dissolved Solids : The total amount of dissolved material, organic and inorganic, contained in water and wastes. The amount of dissolved solids determines the hardness of water.

Ecosystem : A system made up of a group of living organisms and its physical environment and the relationship between them.

Effective Rainfall : It is that part of the precipitation falling during the growing period of a crop that is available to meet the evapotranspirtation needs of the crop.

Effluent : A discharge of polluted water (untreated or partially or completely treated) into the environment.

Endemic : A species restricted to a given geographic location. Native species to a given locale.

Enteric Bacteria : Bacteria which inhabit the intestines including those which may cause disease.

Environmental Impact : An effect of any kind on any component or the whole of the environment.

Estuary : A confined coastal water body with an open connection to sea and a measurable quantity of salt in its water.

Evapo-transpiration : The total water vapour loss by evaporation and transpiration from a vegetated surface over a given period. It lincludes evaporation of water from the soil, from dew and from intercepted precipitation as well as transpiration from plants.

Flocculation : Separation of suspended solids during wastewater treatment by chemical creation of clumps of flocs.

Flood Control Project : A project meant either solely or primarily for flood control purposes, although in the latter case, it may incidentally serve other purposes. It may utilise one or several of the flood control methods. Also called in Australia 'flood mitigation project'.

Gross Area Sown : This is the sum of areas under all crops and represents the sum of net sown area and area sown more than once in the year.

Gross Command Area : The total area including unculturable area under habitation, roads, tanks, wastelands etc covered by a specific irrigation project.

Gross Cropped Area : It is the gross cropped area in a Year. Area cropped two and more times is accounted twice and so on.

Gross Irrigated Area : It is the gross irrigated cropped area in a year. All irrigated areas are counted according to the number of times they are cropped.

Gross Irrigation Requirement : It is the depth of irrigation water required to meet losses in conveyance and application apart from satisfying the evapotranspiration requirements for unhampered maturity of crop on climatological considerations. In the case of paddy, it includes deep percolation requirement also.

Ground Water Draft : It is the quantity of Ground Water withdrawn from Ground Water Reservoirs.

Habitat : The place where an animal or plant naturally lives or grows.

Hydro-Electric Power Project : Project meant solely or primarily for hydro-electric power production, although in the latter case it may incidentally serve other purposes.

Hydrologic Cycle : The continuous circulation of water from the atmosphere through soil to ocean to atmosphere (interrelationships between precipitation, evaporation, groundwater supplies, and water in general).

Hydrological Data : In reference to water resources development, this term refers to data on precipitation, river stages, river discharges, sediment transportation, yield and storage of groundwater, evaporation, valley storage, maximum flood levels and discharges and the quality of water as well as other related meteorological data, such as temperature.

Incineration : Controlled process by which solid, liquid or gaseous combustible wastes are burned and changed into noncombustible gases.

Integrated : As applied to design, planning or operational management, the design, planning or operation of a system of facilities in an interrelated pattern with a view to maximizing economies possible in joint operation.

Integrated River Basin Development : Development of a river basin in its entirety, including, if necessary, transfer or transportation of water, from or to other river basin. The execution of work involved may, however, be taken up in stages.

Integrated River Basin Management : The process of formulating and implementing a course of action involving natural, agricultural, and human resources of a river basin therewith taking into account the social, economic, and institutional factors operating a river basin to achieve specific objectives. It signifies the interactions of components and the dominance of certain components in the particular area.

Intensity of Cropping : This is the ratio of gross (total) area sown to the net area sown expressed as a percentage.

Intensity of Irrigated Cropping : This is the ratio of gross irrigated area to net irrigated area expressed as a percentage.

Intensity of Irrigation : This is the gross irrigated area in an agricultural year expressed as a percentage of the project's culturable command area.

International Water Course : A water course, parts of which are situated in different countries.

Irrigation Cess : In areas where irrigation supplies are not required in years or periods of favourable rainfall conditions and are in demand only when the rains fail or are delayed, an annual charge, known as 'irrigation cess', is levied per unit area irrigable from a project whether water is actually taken for irrigation or not.

Irrigation Project : A project meant either solely or primarily for irrigation purposes including development and improvement of land, although in the latter case, it may incidentally serve other purposes.

Irrigation Potential : Total possible area that has been brought under irrigation, plus that which can be planned for irrigation in a river basin, region or country, from available water resources, with designs based on what may be considered as good technical practice known at the time of assessment of the potential.

Lake : A large body of water contained in a depression of the earth's surface and supplied from drainage of a larger area.

Mangrove : The mangrove is association of halophytic trees, shrubs and other plants growing in brackish to saline tidal waters of tropical and sub-tropical coastlines.

Multiplepurpose Project : Project designed, constructed and operated to serve two or more interests or purposes, namely flood control, hydro-electric power, navigation, irrigation, fisheries, public water supplies, recreation. Project designed primarily for one of these purposes but providing incidental benefits to others is also referred to as multipurpose. It may be individual project, or a part, planned or improvised, of an integrated river basin development.

Net Cropped Area (NCA) : NCA is the net cropped area in an year under reference. Area cropped twice or more times in an year is accounted once only.

Net Irrigated Area (NIA) : NIA is the net irrigated cropped area in an year. All irrigated areas whether cropped once or more in an year are counted once only.

Net Irrigation Requirement(NIR) : NIR is the depth of irrigation water required to satisfy evapotranspiration requirement for unhampered maturity of crop on climatological considerations. It also includes pre-sowing irrigation.

Net Sown Area : This is the total of area sown with crops and orchards counting areas sown more than once in the same agricultural year only once.

Non-consumptive Uses : Those uses of resources that do not reduce the supply.

Non-point Source : A contributing factor to pollution that cannot be traced to a specific spot.

Operation and Maintenance : Operation is the organised procedure for causing a piece of equipment, a treatment plant, or other facility or system to perform its intended function, but not including the initial building or installation of the unit. Maintenance is the organised procedure for keeping the equipment, plant, facility or system in such condition that it is able to continually and reliably perform its intended function.

Overall Irrigation Efficiency : It is the ratio of water beneficially used including leaching water to the quantity of water delivered at canal head. It is the product of conveyance and water application efficiencies.

Overdraft : Amount of water withdrawn from a water resources system in excess of the optimal yield.

Oxidation Ponds : A shallow lagoon or basin in which wastewater is purified through sedimentation, and aerobic and anaerobic biochemical activity over a period of time.

Point Source : A highly localized pollutant source.

Pollutant : Any introduced substance that adversely affects the usefulness of a resource. A residue which has an undesirable effect upon the environment.

Ponds : Generally, suggests a small, quiet body of standing water, usually shallow enough to permit the growth of rooted plants from one shore to another.

Prioritisation : Right to have or do first before others.

Project Cost : The value of goods, services used to investigate, establish, maintain and operate a project.

Project Estimate : An approximate estimate based on full detailed surveys and investigations; for example, an estimate prepared after detailed foundation exploration, surveys over extensive areas for construction materials, alignments and longitudinal sections of channels, detailed designs of works etc., have been completed. In this case too, although the quantities would be forecast with sufficient accuracy, rates of cost which get affected by a variety of unpredictable factors still remain flexible to a large extent.

Public Participation : Citizens or persons outside of the planning or management agencies are involved in the planning. Public participation is a continuous, two-way communication process, which involves promoting full public understanding of the processes and mechanisms through which the problems and needs are investigated and solved by the responsible agency, keeping the public fully informed about the status and progress of studies and findings and implications of plan formulation and evaluation activities and actively soliciting from all concerned citizens their opinions.

Replenishable Ground Water : It is the portion of precipitation which after infiltration percolates down and joins the ground water reservoir.

Reservoir : A pond or lake built for the storage of water, usually by the construction of dam across a river.

Return Flow : It is the part of the irrigation water lost as percolation in water courses and in field application of water and joins the ground water reservoir.

Riparian : Living on or adjacent to a water supply such as a river bank, lake or pond.

River Basin : A geographical area (catchment area) determined by the watershed limits of a water system, including surface and underground water, flowing into a common terminus.

River Basin Development : The orderly marshalling of land and water resources of a river basin for multiple purpose to promote human welfare. It may comprise engineering works and water resources management covering the entire drainage area, from the head-water of a river to the place where it empties into the sea, including all its tributaries, or of a sub-basin consisting of a watershed of a stream from its headwaters to the point where it becomes tributary to a larger watercourse.

River Valley Project : Project directed to developing, controlling or utilising water resources of a river basin.

Sanctuary : An area usually set aside by legislation or deed to observe restriction for the preservation and protection of organisms.

Saprobic : Having to do with decomposed life forms.

Sensitivity Analysis : Assessment of the response of some factors as a result of changes in other.

Sewage : Liquid refuse or water matter carried off by sewers.

Sewage Effluent : The liquid and solid waste carried off with water in sewers or drains.

Sewerage : The removal and disposal of sewage and surface water by sewer systems.

Socio-economic data : In reference to planning and development of water resources project, this term includes overall basic sociological and economic data (population distribution, income, employment, production) and functional data, such as those relating to agriculture, forestry, fishing and trapping manufacturing, mining, recreation, tranportation, power demand, damages from floods, tornadoes, windstorms and coastal erosion and information on water supply, its pollution and public health.

Strategies : The translation of policy statements into general programmes.

Swamp : Wetland dominated by trees or shurbs.

Threshold, or Critical Level : That intensity of stimulus below which there is no response.

Total Dissolved Solids : The total weight of dissolved mineral constituents in water per unit volume or weight of water.

Unaccounted for Water(UFW) : Unaccounted-for water, i.e., the volume of water lost through leakage or irregular practices between entering a distribution system and reaching the users.

Upflow Anaerobic Sludge Blanket (UASB) : Upflow anaerobic sludge blanket (UASB) reactors are an extremely efficient process for the treatment of high-strength industrial, including agro-industrial, wastewaters.

Ultimate Irrigation Potential : Maximum area identified for irrigation from available water resources.

User Charge : Charge made to users of water and waste water systems for services supplied.

Vector : An organism that carriers a disease, parasite or infection.

Volumetric Water rate : The charge levied according to the quantity of water actually delivered to the outlet .

Waste Stabilization Ponds : Shallow man-made basins into which wastewater flows and from which, after a retention time of several days (rather than several hours in conventional treatment processes), a well-treated effluent is discharged.

Waste Treatment : Any process to which wastewater or industrial waste is subjected to make it suitable for subsequent use.

Water Application Efficiency : The water application efficiency is the ratio of the quantity of water stored into the root zone of the crops to the quantity of water delivered to the field.

Water Conveyance Efficiency : This takes into account the conveyance or transit losses. This water conveyance efficiency is equal to water delivered to the farm or irrigation plot divided by the water supplied or diverted from the reservoir or river.

Watercourse : A system of surface and underground waters and constitute, by virtue of their physical relationship, a unitary whole and that flow into a common terminus.

Watercourse State : A country in whose territory part of an international water course is situated.

Waterlogged : Area in which water stands near, at, or about the land surface so that the roots of all plants except hydrophytes are drowned and the plants die.

Watershed : The line separating waters flowing into different rivers, basins or seas. Often used to mean catchment area or river basin.

Watershed Management : The planned use of watershed lands in accordance with predetermined objectives involving the control of erosion, stream flow, sedimentation and the improvement of vegetative cover and other related resources.

Watershed Project : Project consisting primarily of measures to improve ground cover and condition including better cultural practices, shifts in rotations of crops and intensity of land use, strip cropping, contour farming, fire protection land controlled grazing, stream protective measures, afforestation, gully-plugging, stabilization of hill slopes, and other means for the control of natural resources.

Water Policy : Collection of legislation, legal interpretations, governmental decisions, agency rules and regulations and cultural responses which guide a country's actions concerning the quantity and quality of water.

Water Pollution : The addition of harmful or objectionable material causing an alteration of water quality.

Water Quality : A graded value of the components which comprise the nature of water. Established criteria determine the upper and /or lower limits of those values which are suitable for particular uses (organic, inorganic, chemical, physical).

Water Rate : A charge levied on the beneficiaries for supplying irrigation water. It may be based on / or may cover one or more of the following (i) Maintenance and operation expenses. (ii) Amortization charges for the whole or part of the project and maintenance and operation expenses. (iii) Not based on investment costs but on other criteria which may cover or even exceed or may not cover the working expenses and interest on investment.

Wetlands : Areas of marsh, fen, peatlands or water, natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water less than six metres deep at low tide.

Wildlife : It includes any animal, bees, butterflies, crustacea, fish and moths and aquatic and land vegetation which forms part of any habitat.

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