INDIA WATER VISION 2025
Report of the Vision Development Consultation

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INSTITUTE FOR HUMAN DEVELOPMENT
INDIA WATER VISION 2025
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FOREWORD

This exercise was initiated by the Global Water Partnership (GWP) and by the South Asia Technical Advisory Committee of the GWP. At an early stage it was clear that India being a large country with very specific agro-climatic, demographic and development imperatives, some of the global drivers and scenario projectors for India would need considerable modifications. Thus, for example, both the base line estimates and projections made in this exercise and those implied in the south Asia vision of global scenarios are very different. This is evident from a comparison of the projection of this document with those of the south Asia vision of global scenarios.

There is, however, a more compelling reason for undertaking country-level exercises for large countries.

Summming up the proceeding of the UN Millennium conference in Tokyo, the Chief of the Office of Strategic Management of the Secretary General of the UN, saw water as a key issue on which future wars will be fought. As Planning Minister of India, I had set up a Blue Ribbon Commission to detail the perspective of water development. It did a good job and has submitted its report to the government. Being wise men, the members of the Commission did not make any disturbing prediction for the country. They maintained that when the country comes close to its stable projection around 2050, water availabilities may just meet the needs of the time provided we do certain things which are not being done at present. But reading the report one feels as if one is watching a juggler with a number of balls in the air. They base their predictions on the assumption that irrigation efficiencies are improving, water requirements of crops are declining, water
projects are progressing at a faster pace than before, the requirement of water for non-agricultural purposes is minimal and that of population growth is manageable. However, any one of these assumptions may prove to be wrong and this could lead to serious problems. In fact, in a public lecture, Dr. S.R. Hashim, the Chairman of the Commission, who incidently was the first Chairman of the Steering Committee of the India Water Partnership, clearly warned that the country would be faced with a water shortage to the extent of 25 per cent making it imperative for us to start preparing the groundwork for meeting the challenge ahead.

What do we have to do to avoid this catastrophe? The Commission has put together succinctly what some of us have been talking about. India’s crop area has stopped growing, and so a three and half per cent agricultural growth to meet both domestic and export demand will have to come from more intensive use of land and higher productivity, both of which depend on water. In the next ten years the improvement in cropping intensity, which is critically dependent on efficient water use, will have to be greater than the achievement of the last twenty-five years—India will have just two decades to attain the level of intense land use which took East Asian Societies several centuries to achieve. From a cusec of water released from the headwork, 60 per cent have to reach the field as compared to half that level at present. So far only Sardar Sarovar achieved this objective in the experiment at Shedi Branch. What is more important, the many successful ways in which local water sources have been tapped will have to give concrete shape to efficient projects based on state of the art technology.

The definition and mindset of "irrigation", will have to change from releasing water from a headwork of a canal through unlined canals, to modern delivery systems, tanks collecting water from watersheds, check dams, aquifers managed for sustainable water use and the myriad ways in which the farmer has been managing his water needs. The beels, the jheels, the bols and the beautiful vavs and tanks, with
exquisite carvings—same as in the Thanjavur done
millenniums ago, and others as in the Vijayanagar area
beginning from Hampi, centuries ago, will all have to come
back in our consciousness. Irrigation, as defined by Nitin
Desai, in the eighties, will have to mean the number of
waterings in the field, and our irrigation systems will have to
move from the finest dams in the world, combined with
inefficient delivery systems, to accountable operations.

The success stories in water management are no longer
limited in number and run into hundreds and across different
agro-climatic situations. But we need to extend these to cover
millions rather than lakhs of hectares annually as at present.
Two groups, Sadguru in Panchmahals and WOTER in
Maharashtra, have brought over a lack acres under tree cover.
The problem is to lay down rules of support which are
sustainable and allow fast replicability. This may help us meet
the requirements of 360 to 390 km$^3$ by 2025 and around 400
km$^3$ by 2050 from surface water and 253 to 344 km$^3$ from
ground water. Less water-intensive crops and fewer water-
saving devices will be needed to stay at the lower end of
requirements. Though biotechnology for crops and new
materials and better designs for drips and sprinklers are
available, they are not very popular.

The drinking water problem, more often than not, is a
problem of access rather than lack of availability. In spite of
the priority accorded to it by the National Water Policy,
irrigation and industrial-urban use get preference in the
supply of water, and even when it is available for drinking, it
does not reach the poorest. This clearly brings to the fore the
issue of empowerment and administrative sensitivity. In the
success stories, communities with access to water sources have
also participated in managing and maintaining distribution
systems. Proposals for pricing of water are very well taken and
anyway, given the erratic nature of public supplies, studies
show that in urban areas, up to two-fifth of water supplies are
paid for. But leaving poor people to depend on market forces
for the supply of drinking water looks like capitalism with a
vengeance! The answer really lies in properly targeting the subsidies, but in a water distribution system, the leakages will be many. Clearly, this is a problem which we still have to resolve on a priority basis.

The expanding urban needs of water are even more frightening. The official forecasts of urban population, have been reduced from the numbers projected in the Eighth Plan, presumably on the ground that outside Class 1 cities urban growth has declined. But very sensibly the Ministry of Urban Affairs has refused to accept this presumption. As Kirit Parikh and me found in an exercise, even if class 1 cities grow at the rate of between 81/91 and the share of such cities changes as in the past decade, their urban population will cross the 550 million-mark by 2020. If we make the somewhat optimistic assumption that the smaller towns will continue to have the same number of slums while their number will decline in the bigger (million plus) towns, around 120 million persons will still be living in slums. The BOD to be disposed of is truly mind boggling and surprisingly nobody appears to be concerned about it. The Water Perspective Commission has made a provision of 20 km$^3$ of water for the preservation of ecology, which is hopelessly inadequate. The Sabarmati in Ahmedabad, the Khan in Indore and Jamuna in Delhi were once flowing rivers, but are now drains for urban waste, except in the monsoon when the rains wash it away. There are some good studies on them. You need sanitation, recycling, but above all you will need what is euphemistically called the hydrological solution. In other words the cities are going to insist on their share of water and this could lead to widespread violence, unless some wise solutions are found. This can happen if aquifers continue to be managed the way they are. It merits mention here that last year, when farmers surrounded a town in Saurashtra which was drawing water, the police opened fire and three farmers were killed. Clearly, there is a need to create reference community groups of respected elders to whom such flash problems can be referred for giving viable solutions.
The National Rehabilitation Policy Draft has to be adopted, so that reasonable objections to interposing transfer of water can be met. In fact, the Sardar Sarovar pattern, which is preferable since it provides land for those whose land was submerged should be followed. The Prime Minister's formula on the Cauvery is good, because it avoids costly legal wrangles and incorporates a system of providing a political and technocratic solution. It needs to be practised more often.

Finally, India needs to cooperate with its neighbours. We need to work for circles of property and to assure countries like Nepal and Bangla Desh that we are willing to pay the long range marginal cost of water. And, looking at the prosperity enjoyed by countries like Bhutan, through inter-country cooperation in sharing water, hopefully the resistance will be isolated. This is also relevant for energy flows. Here, the fact that India had implemented—when I was Energy Minister—an "availability tariff", for grid flows, will provide a rational basis for trade.

These and other features are discussed in detail in this vision document. The more important task was the way it was put together. To begin with, the document had a distinctly 'global' flavour with an exclusive emphasis on efficiency. While this can still be seen in abundant measure, what was missing, was the development of a Water Vision. The papers by Kashyap, Malik and Goldar provided this perspective, in addition to the institutional and consultant papers listed the different institutions which participated have added to the flavour.

An interesting feature which emerged from the exercise was that global and regional projections generally fail to capture the nature and magnitude of challenges ahead. The regional and global visions on water present perspectives and numbers which are different from the ones presented in this exercise, while their policies are of a more 'general' kind. Also, official approaches tend to shy away from newer experiences and underestimate the nature of the challenges posed. In fact, in a comparison another exercise the Steering Committee saw
that the official approach to 'resources' needed for the framework of action was very different from the one presented by the committee. Since the organisation of the Global Water Forum is still at a preliminary stage, it is hoped that these aspects will get the attention they deserve in the future work in this area.

Yoginder K. Alagh
Chairman
New Delhi and Ahmedabad
18 September 2000
India Water Partnership and Institute for Human Development
ACKNOWLEDGEMENTS

This report is based on the activities of the India Water Partnership which was organised during 1999 by the Institute for Human Development. Prof. D.B. Gupta was the overall coordinator for the activities related to the development and preparation of the vision report. Prof. D.B. Gupta, Prof. Ramesh Bhatia, Dr. R.P.S. Malik, Prof. B.N. Goldar and Prof. S.P. Kashyap wrote background papers and prepared the first drafts. The guidance and insights provided by Prof. S.R. Hashim, the founder Chairman of the India Water Partnership (IWP) and Prof. Yoginder K. Alagh, its present Chairman, throughout the preparation phase of the vision report have been extremely valuable. They advocated a balance between the efficiency and development requirements of the Indian water sector and highlighted the magnitude of key parameters. Prof. Alakh N. Sharma provided useful support towards organising the various activities of the India Water Partnership besides editing the report and arranging for its publication. The important background papers which contribute to the preparation of this report were prepared by Dr. R.P.S. Malik, Prof. B.N. Goldar, Prof. S.P. Kashyap, Dr. S.R. Shukla, Dr. Smita Mishra, Dr. M.S. Reddy, Indian National Committee on Irrigation and Drainage (INCID), National Commission for Integrated Water Resources Development Plan (NCIWRDP), and Indian Water Resources Society (IWRS). The other background material and documents made available by Global Water Partnership (GWP) and World Water Councils have been immensely useful in the preparation of this report.

The South Asia Technical Advisory Committee (SASTAC) provided support to the vision exercise. In the vision
development process, apart from the contributions made by various consultants, researchers, NGOs and government organisations interested in water-related issues, the following institutions made very useful contributions:

Resources and Environment Group, New Delhi; Water and Power Consultancy Services (I) Pvt. Ltd., New Delhi; Water and Land Management Institute, Aurangabad; Planning Commission, New Delhi; Ministry of Water Resources, New Delhi; Central Water Commission, New Delhi; Central Groundwater Board, New Delhi; Indian Council of Agricultural Research, New Delhi; Ministry of Urban Affairs, New Delhi; Rajiv Gandhi Drinking Water Mission, New Delhi; Indian National Committee on Irrigation and Drainage, New Delhi; International Commission on Irrigation and Drainage, New Delhi; National Institute of Public Finance and Policy, New Delhi; Centre for Policy Research, New Delhi; Institute of Economic Growth, Delhi; Agricultural Economics Research Centre, University of Delhi; Sardar Patel Institute of Economic and Social Research, Ahmedabad; National Institute of Urban Affairs, New Delhi; National Council of Applied Economic Research, New Delhi; Centre for Water Resources Study, Patna; Anna University, Chennai; Centre for Science and Environment, New Delhi; Federation of Indian Chambers of Commerce and Industry; Surya Foundation; Pravara Cooperative, Loni; Development Alternatives, New Delhi; United Nations Development Programme, New Delhi; The World Bank, New Delhi; The Ford Foundation, New Delhi; Department of International Development; New Delhi; Water and Sanitation Programme, UNDP/World Bank, New Delhi.

The Report has gone through many transformations from its first draft. Our grateful thanks are due to all persons and institutions listed above.
LIST OF ABBREVIATIONS

BAU : Business as Usual
BCM : Billion Cubic Meter
BOD : Biological Oxygen Demand
CEA : Central Electricity Authority
CETP : Common Effluent Treatment Plant
CPCB : Central Pollution Control Board
FOB : Free on Board
GAP : Ganga Action Plan
GCA : Gross Cropped Area
GIA : Gross Irrigated Area
GOI : Government of India
GWP : Giga Watt Hour
GWP : Global Water Partnership
HUDCO : Housing and Urban Development Corporation
ICMR : Indian Council of Medical Research
INCID : Indian National Committee on Irrigation and Drainage
IWRS : Indian Water Resources Society
LIC : Life Insurance Corporation
NCA : National Commission on Agriculture
NGO : Non-Government Organisation
NIA : Net Irrigated Area
NLCP : National Lake Conservation Plan
NRCP : National River Conservation Plan
NSA : Net Sown Area
PCI : Per Capita Income
SATAC : South Asia Technical Advisory Committee
SPCB : State Pollution Control Board
SWW : Sustainable Water World
UNICEF : United Nations Children Education Fund
WHO : World Health Organisation
WRDP : Water Resource Development Project
WUA : Water Users' Association
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EXECUTIVE SUMMARY

The study presents a comprehensive report on the various processes involved in the development of India Water Vision 2025, and is based on a number of national and zonal level discussions and meetings. The participants in these discussions represented various stakeholders including ministers, senior government officials, academicians, media persons and representatives of NGOs and the private sector.

It was generally agreed in these meetings, that a ‘vision’ represented a ‘desirable future’—something like a cherished dream. It was neither a forecast nor a projection. In the course of the deliberations, two scenarios were considered for India Water Vision 2025: Business as Usual (BAU) and Sustainable Water World (SWW). While a vision was not to be constrained by present-day realities, it was considered important to quantify the implications of the Sustainable World Scenario in terms of food security, livelihood security, health security, ecological security and water resources development.

A number of vision elements were suggested during the course of the national and zonal consultations. Some of the key vision components include: availability of safe drinking water for all near their households so that women and girls do not spend much time in fetching water; perception of water used for meeting the basic needs of cooking, drinking and hygiene as a social good; equity in the use of drinking water; availability of food at affordable prices for the poorest; minimum mortality and morbidity due to water-related diseases; optimum use of
water as per agro-climatic conditions; existence of clean rivers and lakes and water bodies; minimum flows in rivers and minimal inter-state disputes; large dependence on rain water harvesting; minimal pollution from industries and agriculture; effective regional cooperation in sharing of water and energy resources; and effective governance and decentralized management.

The key drivers which influence the outcomes in the above two scenarios were identified and categorised into demographic, social, economic, technological and international/global. For developing scenarios, the following key drivers have been used: population growth; urbanization and the emergence of mega cities; economic growth; zero poverty level and import prices for foodgrains.

The vision elements and key drivers that have been identified are used to develop the two scenarios for 2025 mentioned above. For the Sustainable Water World Scenario, water demands have been estimated as a basis for ensuring (a) food security, (b) livelihood security, (c) health security and (d) ecological security. The total estimated demand for water (gross) for 2025 has been estimated at 1027 BCM. In order to meet these demands water availability will have to be increased from around 520 BCM in 1997 to more than 1000 BCM in 2025. This will necessitate an investment outlay estimated at Rs. 5000 billion during the next twenty-five years or about Rs. 200 billion per year.

Such massive investments in new projects should be planned within the framework of an integrated scheme for river basin development plan. These new projects would enable the transfer of water from surplus regions to deficit regions as well as its storage during water surplus periods so that it can be transferred to various regions during water shortage periods.

However, before such large projects (storage and diversion schemes) are planned and taken-up for execution detailed analysis of the various options for meeting sector-wise demands should be made. Such options should include, inter alia, the following:
Executive Summary

- Reconsideration of life styles, development paradigm and attitudes to consumerism;
- Rainfall harvesting for improving soil-moisture content;
- Measures for optimum production of crop and its sustainability;
- Watershed development;
- Improving water-use efficiency through appropriate technology in irrigation, households and industry;
- Recycling and re-use of treated water.

Further, development of water resource projects would require explicit assessment of environment and social impacts (e.g. rehabilitation of project-affected people). In this context trade-off between development and environment should be directly addressed and appropriate decisions taken to harmonize the conflicting points of view and development philosophies.
BACKGROUND AND PROCESS OF VISION DEVELOPMENT

This report presents the various stages of development of India Water Vision 2025. These broadly cover holding several consultations and meetings with the various stakeholders at the zonal as well as at the national level to identify the themes, scenarios and key drivers governing the water vision. The likely implications of several of these alternatives on water demand for the year 2025 were estimated. In addition, in the process of framing a vision, an attempt was made to provide an investment plan in the "order of magnitude" that would be needed to develop the water resources required to meet the demands of various sectors in the year 2025.

2.1 STAGES IN THE VISION DEVELOPMENT PROCESS
Specifically, the process of vision development consisted of the following steps: (i) holding consultation meetings of various stakeholders, (ii) commissioning of background papers and (iii) review of other related documents. These are discussed below.

2.1.1 Consultation Meetings
The process of vision development was operationalised through a series of zonal and national level consultations. Three national level meetings with stakeholders were organised in New Delhi during March 9-10, 1999; May 17-18, 1999 and June 24-25, 1999. In addition three zonal consultations were held at Aurangabad (for the Western Zone) on June 16, 1999; Chennai
Background and Process of Vision Development

(for the Southern Zone) during June 18-19, 1999 and at Patna (for Eastern Zone) on June 21, 1999. The important objectives of these consultation meetings were:

♦ To provide discussion forums to various stakeholders in water management;

♦ To present to the participants an overview of the World Water Vision process and update them on the progress achieved so far;

♦ To present the scenarios and their underlying drivers used in the Global Water Vision process and elicit from the participants the set of drivers and scenarios relevant for developing the India Water Vision 2025;

♦ To present to the participants the implications of the scenarios for food, livelihood, health and ecological security;

♦ To consult various stakeholders on the basic features of the India Water Vision 2025 that are to be presented at the South Asia Zonal and Global consultation meetings.

All the consultation meetings arranged for framing a 'vision' were very well attended by various stakeholder communities. These meetings were attended by senior government officials both from the central ministries as also from the states, academics, water experts, donor agencies, international organisations (UNICEF, World Bank, etc.), NGOs and industry representatives among others.

2.1.2 Background Papers

The vision development process was initiated with the presentation of thematic papers by well known institutions/policy makers directly involved with these themes. Further work on these themes was based on issues emerging from the following three papers:

1. Water for Food and Rural Development 2025 by Indian National Committee on Irrigation and Drainage (INCID);

2. Water for Health by Dr. S.R. Shukla and Mr. R. Sethuraman; and

The paper on food security emphasised the need to broadly interpret food security to imply a situation where everyone has access, at all times, to the food needed for an active and healthy life. Accordingly, the food security should include the three essential elements viz: adequate availability of food, efficient distribution through trade and/or public distribution system and availability of adequate purchasing power in the hands of the people. The paper suggests that for achieving the goal of food security India should take advantage of the international ‘futures’ in foodgrains, primarily rice and wheat, as a medium of buffer stock management at relatively low volume. There is also a strong case for liberalisation of the trade not only in foodgrains but also in all other agricultural commodities. The paper attempts an estimation of the future demand of water for agriculture.

The second paper on water for health, recognising the fast pace of urbanisation, growing demand and constraints on availability of additional water resources to meet these demands, underlines the importance of making available an adequate amount of safe drinking water to reduce health risks and the incidence of water-borne diseases and thus increase the level of human productivity. To achieve better health impact the paper suggests the adoption of measures aimed at the simultaneous provision of adequate sanitation, control of flies and providing community education about personal hygiene and importance of safe drinking water. The paper then traces the evolution of water supply and sanitation in India, the major policies and institutions governing them and the investments that have been made so far and those that need to be made in future in this sector. To sustain the projected level of investments in these areas, the paper highlights the need for greater cost recovery and also underlines the importance of private sector participation.

The third paper on water for nature, emphasises that Water Resources Development Projects (WRDP) are essential, in
addition to traditional methods of water conservation, to meet the minimum needs of 1.64 billion people on a sustainable basis. Pointing out that WRDPs cause displacement of people, loss of forest, reduction in minimum flow of rivers etc., the paper calls for greater attention to ensure environment and eco-management. The paper highlights some of the important environmental concerns that merit attention which include water logging, salinity control and drainage, agro-forestry, water associated diseases, etc. It then addresses issues relating to the point and non-point sources of water pollution, the steps initiated to monitor water quality and discusses efforts being made to improve water quality. The legal framework for prevention and control of water pollution is also discussed.

The three papers provided useful inputs for initiating a more detailed analysis of certain specified issues required for framing the India Water Vision. To address these issues three papers, each devoted to a specific issue, were specially commissioned. The vision themes covered by the papers were:

1. *Water for Food Security* by Dr. R.P.S. Malik and Dr. S.P. Kashyap;
2. *Water for Livelihood Security* by Dr. R.P.S. Malik and Dr. S.P. Kashyap;

The salient features of the commissioned papers have been briefly dealt with subsequently in this report.

2.1.3 Other Documents

The background material and documents made available by Global Water Partnership and World Water Council formed the basis of the vision exercise. Apart from the background papers and the papers commissioned for the exercise, the process of framing a vision was greatly facilitated by the availability of a large number of relevant documents prepared by the various ministries/departments/commissions both at the centre and in the states, as also by the work of a large number of independent researchers and consultants. Specific invaluable
references in this connection include the following two documents:


2.2. APPROACH TO VISION DEVELOPMENT

The general approach and features of the vision process have revolved around three main aspects, i.e. the basis, nature and time dimension for the India Vision exercise. As regards the basis of the vision, it was agreed that the vision should be based on considerations of a desirable future rather than the present problems of the water sector and its economic, institutional and resource environments. As to the basic features of the vision, two perspectives were visualised: while one strand of opinion placed emphasis on attainability and practicability as the basic features, the other strand of opinion was equally emphatic on the need for a bold vision as a motive force for guiding us to a sustainable water world. However, there was an eventual consensus that the vision should be a dream rather than a projection of things to come in future and should not be constrained by current realities but guided by the requirements of a future generation.

There was also a debate on the time dimension for the vision over whether it should be 2025 or 2050. The target year, 2025 was considered by some to be too short for framing a water vision as many water development projects and institutional arrangements involve a long gestation period. As a result, the target year of 2050 was suggested by some as more realistic for India Water Vision on the following grounds. Not only does this year coincide with the time when the Indian population will stabilise around 1.65 billion\(^1\) but it has also

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1. UN is revising India’s population projections. More recent figures are lower.
been adopted by both National Commission on Integrated Water Resources Development Plan (NCIWRDP) and the Indian Water Resources Society (IWRS) as the target year for their exercise. However, there was a general agreement that a target year should neither be too short nor one that is set too far into the future. While a shorter time span cannot provide the much-needed lead time for preparation, a longer time span may defeat the main purpose of instilling a sense of urgency for taking action. As a result, there was a general convergence on the year 2025 as the target year for India Water Vision.

2.3. IDENTIFICATION OF VISION ELEMENTS

Lengthy and lively discussions were held on the identification of vision elements and a large number of possible vision elements were suggested. Some of the key vision components identified at these meetings and their main features are:

2.3.1 Welfare of the People and Equity

- Ensuring availability of safe drinking water to all near their households and at an affordable price.
- Easy access of women/girls to sources of water, thereby enabling them to fetch water without loss of time.
- Equity in use of drinking water.
- Availability of adequate food at affordable prices for the poorest.
- Absence of famine, and starvation.
- Minimal level of mortality and morbidity due to water-related diseases.
- Minimum gap in per capita availability of safe water between rural and urban areas.

2.3.2 Efficient Use of Water Resources

This will entail:

- Improving effectiveness in the use of water.
- Optimising crop selection as per the agro-climatic conditions so as to minimize water demand.
- Improving crop production technology to enhance crop productivity per unit of water.
- Efficient implementation of integrated watershed management programmes to prevent soil erosion.
- Proper maintenance of water and other infrastructure to ensure sustainable delivery of water services.
- Introduction of pumped storage schemes (with private sector participation) wherever possible in the country for reducing the flow of fresh water into seas.

2.3.3 Decentralisation and Peoples’ Participation
This will necessitate:
- Increased role of women in decision-making on water use.
- Decentralisation—political, administrative and fiscal.

2.3.4 Sustainability and Harmony
This will require:
- Steps to clean rivers, lakes, ponds and other water bodies, thus ensuring the availability of clean and pure water.
- Measures to promote regional/bilateral cooperation.
- Sustained efforts of conflict resolution.
- Absence of inter-state disputes and tribunals.
- Launching of schemes that lay more emphasis on hydro-power, including micro-hydro generation systems.
- Promotion of schemes that ensure minimum flows in rivers and other water bodies.
- Added emphasis on micro-watershed development and rainwater harvesting at the local level for augmenting water supplies.
- Provison of increased storage facilities by arresting run-off/monsoon surplus.
- Preservation and maintenance of existing water bodies, specially tanks, in urban areas.
- Recycling of water with appropriate treatment and strict enforcement of laws relating to effluent discharge by industries.
- Promotion of agricultural practices that reduce the ill effects of the use of fertiliser and pesticides on the environment, i.e. the promotion of integrated nutrient and pest management.


2.3.5 Increasing Role of the Market
This will require:
- Treating water as an economic good (beyond the basic needs).
- Encouraging greater private sector participation.
- Adequate cost recovery measures.

2.3.6 Others Components
These relate to the promotion of water-related activities aimed at boosting tourism, etc.

2.4 RELEVANT SCENARIOS FOR 2025
A major thrust at the consultation meetings was on development of relevant scenarios for India Water Vision 2025 and their specifics and key features. The identification of scenario categories was based on a critical review of the three scenarios used in the global water vision exercise, i.e. the conventional water world, crisis dominated water world and the sustainable water world. At the first stage there was a review of the overall relevance of the three scenarios as characterised in the global vision exercise.

2.4.1 Analytical Framework for Scenario Development
There were also some suggestions on the key features of the analytical framework that could be used to organise scenario development exercises. The general idea in this context involved, first, the identification of all major factors operating on both the demand and supply side of the water sector and then their classification into exogenous and endogenous variables. Some of these factors include the political realities, institutional arrangements including judiciary, social ethos, macro-economic reform and fiscal conditions, technological developments, energy supply and cost, and international factors including trade arrangements, investment flows, technology transfers, technical support from organisations like the Global Water Partnership and World Water Council.

Since all these factors listed above are obviously exogenous to the water sector, the exogenous-endogenous categorisation actually involves grouping of aspects into those that can be
influenced through national policies (endogenous) and those which are outside the influence of national policies (e.g. international politics, global market conditions, climatic change, etc.). Such a categorisation, which is particularly relevant in developing a water vision from a national perspective, allows a systematic generation of variables and parameters, various configurations of which can be used to develop the scenarios that are likely to face the water sector.

2.4.2 Relevance of Global Scenarios for Indian Situation
During the course of discussions, the utility and relevance of the typical business scenario was questioned. It was pointed out that from the viewpoint of the Indian situation even the conventional scenario used in the global water vision exercise itself seems to be too optimistic. Considerable time was devoted to the discussion on the level of sustainability and criteria on the basis of which it is to be defined in the context of the sustainable water world scenario. However, there was an eventual consensus on the following points related to the relevance of the three scenarios for the Indian situation. First, the three scenarios can be accepted on a conceptual basis but they have to be specialised to capture better the Indian situation. Second, the business-as-usual (conventional) scenario is indeed useful not only as a background but also to indicate the cost of inaction. But, it is useful to add the epithet 'business-as-usual' rather than 'conventional' to describe better the base scenario for the Indian situation. Third, the three scenarios corresponding to the Indian situation could be described as: business-as-usual scenario, improved management scenario and sustainable water world scenario. And finally, the sustainable water world scenario could be defined in terms of four criteria i.e. 'equity and poverty alleviation', 'resource sustainability', 'financial/economic sustainability' and 'institutional sustainability'.

2.5 VISION DRIVERS
Wide-ranging discussions were held on identifying vision drivers required for India Water Vision 2025. To identify the set of drivers and their categories that are needed to underpin
Table 2.1  
**Category-Specific Additions of Drivers/ Driver Categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic and Urbanisation</td>
<td>Megacities as a Special Driver</td>
</tr>
<tr>
<td>Socio-Economic</td>
<td>Poverty Alleviation</td>
</tr>
<tr>
<td></td>
<td>Technology Transfer</td>
</tr>
<tr>
<td></td>
<td>Energy-Technology Linkage</td>
</tr>
<tr>
<td></td>
<td>R &amp; D and Innovations</td>
</tr>
<tr>
<td>Economic</td>
<td>Structure of Production</td>
</tr>
<tr>
<td></td>
<td>Industrial Production and Pollution</td>
</tr>
<tr>
<td></td>
<td>Infrastructure Investments</td>
</tr>
<tr>
<td>Social</td>
<td>Values/Equity</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation and Resettlement</td>
</tr>
<tr>
<td>Environmental Issues</td>
<td>Water Quality as a Resource and an Environmental Issue</td>
</tr>
<tr>
<td>Governance</td>
<td>Changing Role of Government (Decentralisation and Privatisation)</td>
</tr>
<tr>
<td></td>
<td>Evolution of Political Systems</td>
</tr>
<tr>
<td></td>
<td>Role of Judiciary</td>
</tr>
<tr>
<td></td>
<td>Water Rights</td>
</tr>
<tr>
<td>Information Data Base</td>
<td>Performance Monitoring and Evaluation both in</td>
</tr>
<tr>
<td></td>
<td>(i) Water Resource Management and (ii) Water Service Deliveries on a</td>
</tr>
<tr>
<td></td>
<td>Continuing Basis</td>
</tr>
</tbody>
</table>

**Additional Category and Drivers**

| International                | Investment and Technology Flow                                          |
|                              | Technical Inputs from GWP/WWC                                            |
|                              | International Trade Agreements                                           |
|                              | Global Conventions/ Commitments                                          |

The scenarios relevant for India, the following approach was adopted. First, the drivers and their categories developed for the global scenarios (Table 1 of the Global Vision Document) were reviewed individually to assess their relevance for the Indian situation. Then, additional drivers and driver categories found necessary in the context of the Indian situation were identified. And, finally, having developed a
comprehensive set of drivers, a manageable subset of them considered to be very critical was identified for use in actual scenario development.

After a critical review of the set of drivers and their categories underlying the global scenarios, it was felt that although some of these drivers are equally relevant for countries like India, others were less relevant for developing national level scenarios. While there was general agreement on organising the drivers at the global level into the following six categories i.e. demographic, technological, economic, social, environmental, and governance categories, it was felt that there was a need to both revise the governance category as well as add a new category of drivers for capturing certain global aspects affecting national policies. The last category (not relevant for global context) is of particular significance for developing scenarios and vision at the national level. With these perspectives, a number of additional drivers as well as additional driver categories were added to the original list in the table presented in the Global Vision. These additions are enumerated in Table 2.1.

After completing the process of identification of the drivers, attention was drawn to the difficulty of developing scenarios based on a large set of drivers. It was then agreed to identify a key set of drivers that were likely to be very critical for the purpose of developing realistic and operationally tractable scenarios for vision exercise. The discussions in this regard assigned top priority to the following drivers and driver categories:

1. Population growth, pattern, and migration.
2. Urbanisation, especially the impact of mega cities.
3. Economic growth, economic reforms and income distribution.
4. Structure of agricultural and industrial production.
5. Poverty alleviation and meeting basic needs.
6. Role of government, administrative decentralisation, user participation, referendum and privatisation.
7. Empowerment of communities.
4. Control financial resources by Gram sabhas.
5. Institutional change, water law, water policy and water administration.
6. Technology transfers and R&D and innovations in water and energy technologies.
7. International trade pattern and investment flows.
8. Implementation of regional planning.
11. Water management of water surplus areas.

2.8.1 Numerical Values for Key Drivers

The following numerical values for the key drivers were taken to estimate the demand for food, health care facilities, preservation of ecology, etc. and for working out the implications of these for the demand for water. The values were determined on the basis of a review of relevant literature on the subject and discussions on the same. These values are detailed in the Table 2.2.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP Growth</td>
<td>7 per cent per annum</td>
</tr>
<tr>
<td>Population Growth Rate</td>
<td>1.62 per cent till 2001</td>
</tr>
<tr>
<td></td>
<td>1.57 per cent till 2006</td>
</tr>
<tr>
<td></td>
<td>1.50 per cent till 2025</td>
</tr>
<tr>
<td>Urbanisation</td>
<td>45-55 per cent</td>
</tr>
<tr>
<td>Poverty Level</td>
<td>Zero</td>
</tr>
</tbody>
</table>
The issue of population growth and its implications for the water sector were discussed at length. One view was that population growth held the key to the future demand-supply balance in water, and therefore containing population growth was very important to maintain this equation. Accordingly, it was suggested that a low rate of growth of population in the coming years could be taken as a part of the vision. The majority opinion was, however, opposed to this suggestion. It was argued that even if a major initiative is taken now, it would be difficult to change substantially the dynamics of population, and it is safe to assume that the growth rate of population will come down-slowly.

The water vision for the future crucially hinges on the lifestyle of the Indian people in the years to come. Going by the present trends, which are marked by increasing ‘consumerism’ and imitation of the western lifestyle with its accent on material comfort, there will be growing pressure on the natural resources, including water. To meet the ever-increasing requirements of water, a large number of major water resource development projects have to be undertaken taking a heavy toll on the environment. The mounting pressures of these developmental activities on the resource base, some feel, can lead to disaster. The alternative path is one of austerity, which will no doubt ensure both economic and environmental sustainability.

While recognising the merit of an austere lifestyle, many participants in the consultation meetings were of the opinion that this cannot be taken as the basis for formulating the vision. Rather, it is more realistic to assume that the living standards of the people will significantly improve over time. While it need not be an unduly luxurious lifestyle, it would be one associated with modest comforts. With increasing population and rising living standards of the people, there would be increasing demand for goods and services. This will inevitably lead to a rise in the demand for water to meet the domestic needs of water and the water requirements of the producing sectors such as agriculture.
The implications of alternative scenarios for each of the four major components viz. Food Security, Livelihood Security, Health Security and Ecological Security were assessed for the year 2025 in terms of demand and supply of water, threats and challenges. Investment requirements for developing the required water infrastructure, sustainability of these investments, implications of cost recovery from users, and institutional requirements were also assessed. As mentioned earlier, papers dealing specifically with each of these issues were commissioned. Their findings are summarised below.

1.1 WATER FOR FOOD SECURITY
Irrigation in India has played an important role in enhancing crop yields, in accelerating the growth in production and in providing stability to agricultural production by reducing annual fluctuations caused by vagaries of weather. While the estimates of the contribution of irrigated agriculture to agricultural production vary, some of those available suggest that irrigated agriculture, with less than one-third of the gross cropped area, contributes more than 75 per cent of the total foodgrain production and about 95 per cent of the non-foodgrain production of the country. The growth in food production has so far kept pace with the growth in population and the increasing need for food security for the ever-increasing population of India.
With increasing population and virtually no new area available for extension of cultivation, India faces a tough challenge in the coming years in meeting the rising demand for food and fibre for its rising population and tapping the export opportunities made available by a more liberalised trading world. Increasing crop production per unit of land appears to be the only way of increasing agricultural production and meeting the future demands of these commodities. With the prospects of any major technological breakthrough in crop production being bleak in the near future, irrigation appears to be the major driving force for realising increased agricultural production from the available land and in providing food security for the country. Irrigation, however, must grow at rates faster than it has grown in the past.

Apart from ensuring food security, faster growth in the irrigation and agriculture sector is also needed to (a) provide employment opportunities for the rising population, (b) keep the prices of foodgrains under control, (c) raise income levels of the poor and (d) help the poor to overcome their poverty and misery. However, given the limited availability of water in the face of rising demand for water from various sectors of the economy, the question that arises is: will we have sufficient quantity of water to grow enough food and non-food crops? Given the critical financial position of the Indian irrigation sector and the constraints on the availability of fresh investible resources, how will the huge investment required to develop the needed irrigation be financed?

We attempt here an assessment of the likely demand for foodgrains in the year 2025 keeping in view the increasing population and provide, in order of magnitude, an estimate of the likely increase in irrigated area that would be required to meet this projected demand. We then make an estimate of the likely demand for irrigation water in the year 2025 and the likely investment that will be required to create the necessary irrigation infrastructure. In the last section we discuss some of the possible implications of these changes in the area under irrigation and the agricultural scene in terms of assuring a secure livelihood to the increasing population.
1.1 Foodgrain Demand Scenarios for 2025

The demand for foodgrains in any country is determined by a host of factors. Amongst these, the crucial ones are the population size and its growth, rate of change in per capita income (PCY), process of urbanisation, changes in dietary patterns and their effects on feed coefficients, and pattern of income generation and changes therein. Food projections can be based on trend projections, or simulated for different sizes and classes of consumers (given information on budget shares and expenditure elasticities for different food items) under varying assumptions about growth of PCY, population, or urbanisation. Alternatively, they could be determined on the basis of normative considerations, such as the need to eliminate poverty under varying PCY growth or provision for a “well-fed” India.

We do not generate any fresh estimates. Instead, we briefly report the findings of two recent studies and draw implications for the Indian economy, particularly on aspects related to food security, and well-being of the vulnerable sections. The studies referred to are those by Ravi (1998) and Bhalla and Hazell (1997).

The two studies differ in many ways, but both give valuable insights into future food demand patterns under varying assumptions. They vary in approach and sophistication also. Ravi’s estimates are based on an elaborate model, where prices and marginal budget shares (particularly between food and non-food, apart from composition changes in food basket for five expenditure classes) are important as constraints and also have a determining influence. Ravi, however, makes no normative judgement about poverty removal, except that the PCY growth itself may offer a solution. On the other hand, the Bhalla-Hazell (BH) study involves a straightforward application of expenditure elasticities under varying PCY growth (3 per cent, 5 per cent). It may be noted that expenditure elasticities used by the two studies are not too dissimilar. BH nonetheless introduce important dimensions to the projections for foodgrains demand based on the following assumptions:
(1) Continuation of current trend (3 per cent growth in PCY).

(2) **Poverty removal** : Using base year data (1987-88) the consumption basket of all expenditure groups below the poverty line, separately for rural and urban population, is altered to the consumption basket of the group lying just above the poverty line. They then calculate the revised averages for the expenditure bundles of the rural and urban population, which form the basis for calculating the impact of changes in population and income growth in 2020.

(3) **Well-fed India** : A poverty reduction scenario in which everyone among the malnourished (particularly from protein deficiency) is allowed to be well-fed. For this study they take food consumption basket recommended by the Indian Council of Medical Research (ICMR) as the desired minimum. Projections are then made on the lines of this approach as in (2) above.

**3.1.2 Some Important Findings**

(i) **A Vision exercise has to have at its core a non-poor India.** Ravi’s study is based on normative assumptions about poverty removal. His estimates at the same time show that a high and sustained growth in PCY, even with the existing pattern of growth accompanied with invariant inter-class inequalities in expenditure distribution, would, by 2025, significantly reduce the proportion of population living below the poverty line. In rural India the projected reduction, depending upon the PCY growth, is from 38 to less than 6 or 2 per cent. Similarly, in urban India this is from 18 per cent to 4 per cent or less than 2 per cent. The other notable change that occurs is the clustering of population in the non-poor or well off class. At 4 per cent PCY growth this concentration is around 70 per cent of the population, which raises to close to 85 per cent at 5 per cent PCY growth.

Growth in PCY not only has implications for poverty removal but significantly alters India’s consumption basket by
In the terminal year, compared to the base year, there is a two-fold increase in foodgrain demand (including feed), a four-fold increase in the consumption of milk and milk products and more than a three-fold increase in the consumption of edible oils, meat and fish, sugar and gur and fruits and vegetables. The consumption basket is quite responsive to changes in the rate of growth of PCY. For instance, if PCY grows at 5 per cent instead of 4 per cent, aggregate food consumption would increase by as much as 8 per cent over the projection period, though the corresponding changes are much higher for non-food items, like milk and milk products (27), sugar or gur (25), fruits and vegetables (24).

Based on Ravi’s work, NCIWRDP estimates foodgrain demand by varying PCY growth, population size and its composition. The NCIWRDP, in order to calculate the required production, allows for an addition of 15 per cent for carryover from a good monsoon year to meet the shortages of foodgains and the requirements for seed, wastage, etc. During a bad monsoon year the annual foodgrain production requirement under different assumptions varies from 331 million tons to 365 million tons. The total feed demand varies within a narrow range of 11 to 14 million tons. Apparently, NCIWRDP does not expect animal feed practices to alter much as the consumption basket grows along with changes in its contents.

3.1.3 Food Security Versus Free Trade in Agriculture

The foodgrain demand projections as cited above do not take into account the implications of lifting global trade shackles. One reason for this could be that in a long-term perspective it is difficult to predict global trends with precision. A more important reason is that in a country where one-third population still languishes in abject poverty, food security has been an overriding objective. Let us briefly examine the issues involved.

There is considerable optimism in some quarters about global opportunities. Consider a quote from Moddie’s (1995, as cited
by Rao: 1996, p. A59) wide-ranging review of agricultural policies and prospects: "Threshold of Indian enterprise can be developed between farmer, industry and bank in a wide field of farming enterprise for both India and export markets. These opportunities exist in oilseeds, cotton, marine products, poultry, cashew kernels, vegetables, fruits, mushrooms and floriculture, apart from the traditional plantation industries of tea and coffee. The essential common factor of such a diverse field is that each case has to be treated as an enterprise from farm to factory to market, with adequate investments, high productivity, competitive costs and prices, quality control and marketing. Viable profitability has to be the terminus of that road." Moddie believes that a target of Rs. 200 billion for annual farm exports can be achieved in five years provided the policies are clearly defined and strengthened.

In this respect existing cropping patterns need not be viewed as sacrosanct. Rao (1996) cites from Desai's (1993) work: "Food self-sufficiency at any cost is regarded as sacrosanct; agriculture happens to be the victim of this shibboleth at a time when attitudes towards industry have become much less protectionist... agriculture employs or harbours a large proportion of the poor; hence policies towards it carry a borrowed tinge of anti-poverty programmes."

The assumption of a small country that forms the basis of neo-classical trade theory is not valid in the case of India. This is because India is a major producer and consumer of most of the agricultural commodities. Second, a relatively small proportion of world output enters into world trade for most agricultural commodities. A major participation by India in such a world trade is bound to depress in terms of trade (Nayar and Sen: 1994). For instance, it can be seen that if India exports more than 5 per cent of its rice output it would augment world market supplies by 25 per cent, thereby exerting downwards pressure on the prices.

The optimism about free trade having a favourable impact on Indian farm sector inducing high income and employment gains is also disputed on the basis of available facts such as:
(a) The Punjab agriculture, in spite of being the most advanced in the country, is not internationally competitive in wheat and rice due to high costs involved and the resultant wide gap between the farm gate prices in the state and FOB prices. "Under the present production technology, marketing and handling system and tax structure, accompanied by double digit inflation, has eliminated whatever advantages the country could acquire in these two commodities following massive devaluation of rupee in 1991" (Gill and Brar: 1996, p. 2176).

(b) Long-term projections about foodgrains demand in India show that stupendous efforts would be required for stepping up food production even if domestic demand is to be satisfied from domestic sources (Bhalla and Hazell: 1997).

(c) Area allocation at the margin for foodgrains at the cost of oilseeds, as argued by Gulati and Sharma (1997), ignores the fact that marketable surpluses from wheat and rice mainly come from gravity-based watered areas of Punjab, Haryana, Western U.P. and Andhra Pradesh, whereas oilseed growers are mostly resource poor and/or dry land farmers.

(d) The outcome of a dynamic nine-sector, seven-income classes computable general equilibrium model indicate that... “the gains from (agricultural) trade liberalisation may not be as large or as unambiguous as some partial and general equilibrium analyses suggest. In particular, if the trade reforms are not supplemented by a supportive agricultural policy, medium-term stagflation may be the result. Even in case the reforms are supported by an aggressive agricultural policy stance, the outcome is marginally contractionary but in terms of distribution significantly regressive. It is, therefore, not at all obvious that India should go in for a wholesale liberalisation of its agricultural trade” (Storm: 1997, p. 435).

(e) The ability of the agricultural sector to finance increasing
food imports through agro-export earnings is highly doubtful in view of the existing and projected trend in the price of cereals relative to non-cereal agro export commodities. This is because... "the cereals trade-dominated by advanced countries, is characterised by monopoly and monopolistic pricing (advanced countries as a group closely monitor and co-ordinate their output and inventories while subsidising their farmers) whereas the agro-export trade in the major commodities producable in tropical and sub-tropical developing areas is characterised by enforced competition" (Patnaik: 1997, p. 1108). It may be mentioned that bulk of the most commodities market in the world trade are handled by less than 5 to 6 muti-commodities traders (Clairmount and Cavanagh: 1998, Table 1.8).

3.1.4 Agricultural and Foodgrain Scenario : An Overview
Before setting out the implications of projections for 2025, we give below some background of the foodgrain production scenario in India. During the period between 1970 to 1995 spanning two and a half decades, several-important changes have taken place in the Indian agricultural scenario in general and foodgrain production scenario, in particular. Some of the important changes are classified into three broad groups, viz. changes in area, changes in production and changes in underlying factors, principally in the availability of irrigation (Table 3.1), as detailed below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (Million)</th>
<th>Per Capita Foodgrain Area (ha)</th>
<th>Per Capita Foodgrain Production (kgs)</th>
<th>Foodgrain Prodn/ Ha of Foodgrain Area (quintals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>551</td>
<td>0.23</td>
<td>196</td>
<td>8.71</td>
</tr>
<tr>
<td>1981</td>
<td>689</td>
<td>0.18</td>
<td>189</td>
<td>10.24</td>
</tr>
<tr>
<td>1991</td>
<td>852</td>
<td>0.15</td>
<td>207</td>
<td>13.75</td>
</tr>
<tr>
<td>1995</td>
<td>916</td>
<td>0.14</td>
<td>210</td>
<td>15.48</td>
</tr>
</tbody>
</table>
Changes in Area under Cultivation

The salient features of changes in the availability of area under cultivation during the period are:

- The Net Sown Area (NSA) has remained almost constant at around 143 million hectares (mha)—in fact, it fluctuated within a narrow range of 140 to 143 mha during this period.

- The Gross Cropped Area (GCA) during the period has increased by about 22 million hectares—from 166 mha to 188 mha—as a result of an increase in cropping intensity from about 118 in 1970 to about 132 in 1995.

- The increase in the availability of GCA has been accompanied by changes in cropping pattern and in the proportion of area allocated to foodgrains and non-foodgrain crops. While the proportion of cropped area allocated to foodgrains has declined over the period from about 75 per cent in 1970 to about 66 per cent in 1995, that under non-foodgrains has increased from 25 per cent to more than 34 per cent.

- An important feature of the reallocation of the cropped area between foodgrains and non-foodgrains has been that the absolute area allocated to foodgrains has remained almost unchanged throughout the study period. The area under foodgrains during the period fluctuated within a narrow range of 124 to 128 mha—averaging around 125 mha.

- Most of the increases in the availability of cropped area during the period have gone for the cultivation of non-foodgrain crops.

- Although the absolute area under foodgrains has remained almost constant during the period under review, some reallocation of the available foodgrain area amongst different foodgrain crops has nevertheless taken place. As a result, the combined area under rice and wheat has increased from about 56 mha in 1970 (45 per cent of total foodgrain area) to about 69 mha in 1995 (about 55 per cent of total foodgrain area). The increase in the area under rice and wheat has come about mainly as a result of a decline in the area under coarse cereals from 46 mha to 32 mha.
While the area under foodgrains remained constant during the period, the population of the country increased by more than 66 per cent—from 551 million to 916 million. As a result, the per capita availability of foodgrain area during the period declined steeply from 0.23 ha to 0.14 ha.

(ii) Trends in Foodgrain Production

The salient features of changes in foodgrain production scenario during the study period have been the following:

- While the total area under foodgrains remained almost constant during the study period, the production of foodgrains increased significantly, partly as a result of reallocation of available foodgrain area amongst different crops and partly as a result of increase in crop yields per unit of land. The foodgrain production during the period increased from 108 million tons (mt) in 1970 to 192 mt in 1995. The average foodgrain production per hectare of area increased from 8.71 quintals per hectare to 15.48 quintals per hectare.
- The combined production of rice and wheat during the period increased from 66 mt to 148 mt, while that of coarse cereals remained constant at around 30 mt. As a result, the share of rice and wheat in the total foodgrain production increased from 61 per cent to 77 per cent during the study period.
- The per capita production of foodgrains (as distinct from the per capita availability) during the period increased from 196 kgs to 210 kgs.

(iii) Factors Contributing to Increased Foodgrain Production

- The increase in foodgrain production, with foodgrain area remaining almost constant, is the interactive outcome of a number of contributing factors—increases in area under high-yielding varieties, increased use of chemical fertilisers, extension of irrigation facilities to newer areas, investments in research and extension, infrastructure development, etc.
- Due to the complementary nature of different factors of production it is difficult to either ascribe the resultant
increases in foodgrain production to a given factor of production or to rank the relative importance of different factors of production in contributing to the increased foodgrain production. The availability of irrigation has nevertheless been recognised as a pre-requisite for the adoption of other yield-increasing technological inputs.

### 1.1.5 Growth in Irrigation

Some of the important changes witnessed during the period under consideration on the irrigation scene are as follows:

- There has been a substantial increase in the availability of irrigated area. While the net irrigated area (NIA) has increased from 31 mha to 53 mha (an increase of 71 per cent) the gross irrigated area (GIA) has increased from 38 mha to 71 mha (an increase of about 87 per cent).

- Both surface water and groundwater have contributed to the increase in the availability of irrigated area. However, over the years their relative contributions to the total irrigated area available, have changed. While the contribution of surface water sources to the NIA during the period declined from 62 per cent to 46 per cent, that of groundwater increased from 38 per cent to 54 per cent.

- Concurrent with the changing contribution of different sources of irrigation to the total irrigated area available, there have been changes in the allocation of the available irrigated area between foodgrains and non-foodgrains. The share of foodgrain area irrigated in the GIA available during the period declined from about 79 to 69 per cent while that under non-foodgrains increased from 21 to 31 per cent. In absolute terms, however, the irrigated area under foodgrains and non-foodgrains during the period increased by about 19 mha and 13 mha respectively.

- An analysis of the decomposition of additions to the availability of GIA between foodgrains and non foodgrains suggest that while during the initial period—between 1970-71 to 1975-76—almost 77 per cent of the total additions to the availability of irrigated area went for the cultivation of
foodgrains, more recent—between 1990-91 and 1994-95—the increases in the availability of GIA have been shared equally by the foodgrains and non-foodgrains.

- During 1994-95, of the 124 mha of area under foodgrains, 49 mha (about 40 per cent) was irrigated while the remaining 75 mha (about 60 per cent) was still under rainfed conditions.

- Of the 49 mha irrigated area under the foodgrains during 1994-95, more than 43 mha were allocated to rice and wheat. The proportion of rice area irrigated over the study period has increased from about 38 per cent to 50 per cent, while the proportion of wheat area irrigated has increased from 54 to 85 per cent. The proportion of non-foodgrain crops irrigated increased from 20 to 34 per cent.

3.1.6 Projections for Year 2025—Some Assumptions
While drawing up plausible scenarios for year 2025, it is important to emphasise that as the population continues to increase, the land area will remain more or less constant. The rising population, increasing income levels and the changing lifestyles will put greater pressure on available land area for housing, industrial development, infrastructure development, etc. As a result the agricultural sector is likely to face increasing pressure to release part of the available land currently under cultivation for other sectors of the economy.

The data presented above clearly show that there has been absolutely no increase in NSA available in the last two and a half decades. In future it may be difficult to keep the cultivated area at this level let alone expect any increase in its availability. It will thus be fair to postulate that no new area will come under agricultural production and in the most favourable scenario no area currently under agriculture will be diverted to any other use. We, therefore, assume that the NSA available in year 2025 will be equal to that currently available, viz around 143 mha.

With virtually no scope for an increase in the availability of NSA, there will be greater pressure to cultivate the available land more intensively. As such the cropping intensity is
expected to rise, albeit at a somewhat slower rate, resulting in increased availability of GCA. During the period between 1970-71 to 1994-95 the cropping intensity has varied between 118 to about 134 per cent. We assume that cropping intensity in the year 2025 would be about 145 per cent. As such the GCA in 2025 will be about 210 mha as against 188 mha currently.

If the current trends are any indication, increases in GCA do not necessarily imply a corresponding increases in the area under foodgrains. In fact, in the last twenty five years almost all increases in the GCA have been diverted for cultivation of non-food crops with the area under foodgrains varying within a narrow range of 123 mha to 128 mha averaging around 124 mha. It will thus be reasonable to assume that the cropped area under foodgrains in year 2025 will also remain at the current average level of around 124 mha.

Thus, given the likely limits on availability of NSA and cropped area for cultivation of foodgrains at levels approximately equivalent to those currently prevailing, achieving the required increases in foodgrain production for the ever-increasing population would require a significant step up in average crop productivity of foodgrains. Assuming that no major technological breakthrough in foodgrain production may occur in the near future, the major source for increasing crop yields lies in extending irrigation to larger foodgrain areas. Currently, of the 124 mha cropped area under foodgrains, 49 mha (about 40 per cent) is under irrigation while the remaining 75 mha (60 per cent) is still cultivated under rainfed conditions. The extension of irrigation facilities to at least a part of this rainfed area thus offers a possible avenue for realising the objective of increased foodgrain production.

3.1.7 Requirement of Irrigated Area for Foodgrains

Given that further increases in foodgrain production are likely to come about mainly through an increase in the irrigated area under foodgrains, we need to work out the extent of foodgrain area, currently under rainfed conditions, that would need to be brought under irrigated conditions.
The 1992-93 national average foodgrain yield was 2.4 tonne per hectare under irrigated conditions and 1.0 tonne per hectare under rainfed conditions. Assuming that there is no major technological breakthrough, the average foodgrain yields will continue to increase at the current rate of about 1 per cent per annum under both irrigated and rainfed conditions. As such the average foodgrain yields under the two cultivating conditions are likely to be of the order of 3.4 and 1.25 tonne per hectare respectively in the year 2025 (NCIWRD: 1999).

In the absence of any new addition to the available foodgrain area and with no change in the proportion of irrigated and rainfed foodgrain areas, the foodgrain production in the year 2025 would be of the order of 260 mt. Depending upon the underlying assumptions for foodgrain requirements in the year 2025, this scenario would leave a requirement-supply gap of between 72 to 105 mt.

Matching supply with requirement of foodgrains will thus require increasing the irrigated area under foodgrain through the conversion of rainfed area to irrigated area. The estimates derived suggest that, depending upon the level of demand assumed, between 33 to 48 million ha of foodgrain area currently under rainfed conditions would need to be brought under irrigated conditions. This would thus alter the proportion of irrigated and rainfed foodgrain area from 40-60 per cent currently to 66-34, 73-27 and 78-22 per cent respectively under the three demand scenarios in the year 2025.

3.1.8 Contribution of Different Sources of Irrigation and Demand for Irrigation Water

Having estimated the irrigated area requirement for production of foodgrains, we need to work out the implications of these changes on demand for irrigation water. Estimating the demand for irrigation water, however, requires reasonable assumptions about the likely contribution of surface water and groundwater to the additional irrigated area under foodgrains.

An examination of the past data on relative contribution of surface and groundwater to the NIA suggest that over the years
the relative contribution of surface water has been declining while that of groundwater has been increasing. In the year 1994-95, about 46 per cent of NIA was irrigated by surface water while the remaining 54 per cent was irrigated by groundwater sources. We assume that the relative contribution of surface and groundwater will change over the years and the surface water will play a relatively more important role on the years. The contribution of surface water to the total irrigated area under foodgrains in the year 2025 will be 55 per cent and the remaining 45 per cent will be irrigated by groundwater sources.

For estimating the water demand for irrigation, we use the average weighted value of irrigation ‘delta’ at 0.70 meter for surface water and 0.52 for ground water (NCIWRD:1999). The estimated irrigation water requirement for meeting the irrigation needs of the projected area under foodgrains in the year 2025 works out to 507, 558 and 600 BCM respectively for the three demand/production scenarios formulated for foodgrains.

3.1.9 Estimated Increases in Irrigated Area under Non-Foodgrains
An analysis of the past data on allocation of increases in the availability of gross irrigated area between foodgrains and non-foodgrains suggest that over the years, increases in availability of GIA have been accompanied by increases in GIA under foodgrains as well as non-foodgrains. In fact the ratio of GIA under non-foodgrains to GIA under foodgrains has been rising consistently from about 0.27 in 1970-71 to about 0.44 in more recent years. We, therefore, assume that concurrent with increases in irrigated area under foodgrains, the area under non-foodgrains will also rise and the ratio of irrigated area between non-foodgrains and foodgrain crops will be maintained at 0.44 in the year 2025. Thus, irrigated area under non-foodgrain crops in year 2025 is estimated to increase to between 36-43 mha from the current level of 22 mha.

Making similar assumptions about the relative contribution of surface and groundwater sources to increases in irrigated
area under non-foodgrain crops, as in the case of foodgrains, and similar assumptions about irrigation delta the estimated demand for irrigation water for non-foodgrains in year 2025 work out to 223, 248 and 267 BCM corresponding to the three demand scenarios for foodgrains.

3.1.10 Water Availability and Demand for Irrigation Water
The utilisable water resources for the country as a whole have been estimated at 1086 BCM comprising of 690.3 BCM from surface water sources and the remaining 395.6 BCM from groundwater sources. The estimated total demand for irrigation water for foodgrains and non-foodgrains in the year 2025 work out to 731, 806 and 867 BCM for the three demand scenarios of foodgrains (Table 3.2). The total demand for irrigation water

<table>
<thead>
<tr>
<th>Year/ Scenario</th>
<th>Total Irrigated Area (mha)</th>
<th>Irrigated Surface Water (mha)</th>
<th>Irrigated Ground Water (mha)</th>
<th>Surface Water Required (BCM)</th>
<th>Ground Water Required (BCM)</th>
<th>Total Water Required (BCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994-95</td>
<td>71</td>
<td>32.5</td>
<td>38.5</td>
<td>227.5</td>
<td>200.2</td>
<td>427.7</td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>118</td>
<td>65</td>
<td>53</td>
<td>455</td>
<td>275.6</td>
<td>730.6</td>
</tr>
<tr>
<td>D2</td>
<td>130</td>
<td>72</td>
<td>58</td>
<td>504</td>
<td>301.6</td>
<td>805.6</td>
</tr>
<tr>
<td>D3</td>
<td>140</td>
<td>77</td>
<td>63</td>
<td>539</td>
<td>327.6</td>
<td>866.6</td>
</tr>
</tbody>
</table>

works out to between 67 and 80 per cent of the total utilisable water resources, thus leaving between 219 to 355 BCM for meeting the demand of other water-using sectors (Table 3.3).

3.1.11 Investment Requirements for Meeting the Projected Irrigation Water Demand
Having estimated the requirement of irrigated area for meeting the projected level of foodgrain demand in the year 2025, we now attempt to provide 'order of magnitude' estimates of the capital cost of creating the required infrastructure to meet the projected level of demand for irrigation water.
Table 3.3
Available Water Resources and Demand for Irrigation: Year 2025 (BCM)

<table>
<thead>
<tr>
<th></th>
<th>Surface Water</th>
<th>Ground Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total utilisable Water</td>
<td>690.3</td>
<td>395.6</td>
<td>1086</td>
</tr>
<tr>
<td>Demand for Irrigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Scenario D1</td>
<td>455 (66)</td>
<td>275.6 (70)</td>
<td>730.6 (67)</td>
</tr>
<tr>
<td>— Scenario D2</td>
<td>504 (73)</td>
<td>301.6 (76)</td>
<td>805.6 (74)</td>
</tr>
<tr>
<td>— Scenario D3</td>
<td>539 (78)</td>
<td>327.6 (83)</td>
<td>866.6 (80)</td>
</tr>
<tr>
<td>Water Available for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Uses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Scenario D1</td>
<td>235.3 (34)</td>
<td>120 (30)</td>
<td>355.4 (33)</td>
</tr>
<tr>
<td>— Scenario D2</td>
<td>186.3 (27)</td>
<td>94 (24)</td>
<td>280.4 (26)</td>
</tr>
<tr>
<td>— Scenario D3</td>
<td>151.3 (22)</td>
<td>68 (17)</td>
<td>219.4 (20)</td>
</tr>
</tbody>
</table>

The Planning Commission estimates that the capital cost of providing irrigation water for one hectare of land through major and medium sources of irrigation at current prices work out to Rs. 66,570. Some researchers have, however, questioned the Planning Commission methodology for estimating the capital cost of providing irrigation and have argued that the Planning Commission estimates grossly underestimate the actual cost of creating this infrastructure. The Central Water Commission is also of the opinion that these figures underestimate the actual cost of development of new water resources. Notwithstanding the merits of the different estimates available, and recognising the need for a fresh look at the estimates, we have used the Planning Commission estimates for the present exercise.

In contrast to the high costs associated with providing irrigation through major and medium sources of irrigation, the cost of providing water through minor sources of irrigation—tubewells—is relatively much less. The average capital cost of providing irrigation through groundwater sources for the present exercise has been taken, at a conservative level, to be Rs. 20,000 per hectare. This estimate, however, does not include the implications in terms of requirement of electricity for
pumping groundwater and associated cost of supplying electricity for running the tubewells.

The capital cost of creating the required irrigation infrastructure for meeting the irrigation water requirement has been estimated under three demand scenarios for foodgrains. The estimates obtained suggest that huge investments of the order of Rs. 1268 to Rs. 1764 billion will need to be made to achieve food security in year 2025. The total investments required for bringing the projected food and non-foodgrains area under irrigation would be of the order of Rs. 1821 to Rs 2560 billion.

3.1.12 Irrigation Investments : Towards Financial Viability and Sustainability
The huge financial investments needed for expansion of irrigation to meet the desired level of food production calls for stricter financial discipline and reforms in the management of irrigation services. The current financial crisis of the irrigation sector is attributable to and characterised by inadequate budgetary allocations, low irrigation water rates and their poor recovery, inadequate maintenance of irrigation works, meagre financial resources available for O & M, highly subsidised electricity for irrigation pumping, absence of any groundwater extraction charges, etc. To a large extent they can be attributed to inefficient management of irrigation works, overstaffing in irrigation departments, lack of well developed institutions and lack of involvement of beneficiaries in the management of irrigation works.

The ‘business as usual’ scenario of the irrigation sector, characterised by the above mentioned financial and management maladies, if allowed to continue, will add to the already severe financial crisis and make the perceived financial investment financially unviable and unsustainable. Sustaining the huge investment envisaged for the irrigation sector would require moving towards an ‘improved management’ scenario incorporating improvements in the management of finances and operations of the irrigation services. Improved financial
management of irrigation sector involves initiating steps towards rationalisation of water rates to fully recover O & M expenses from the beneficiaries, increasing electricity rates to a level that each fully recover O & M costs and at least 50 per cent of the capital cost, introduction of groundwater extraction charges, etc. (Table 3.4). Concurrent with steps to enforce financial discipline, institutional reforms will need to be initiated for better management of irrigation water. These reforms, though a significant improvement over the current state of affairs, fall short of the goal of attaining a ‘sustainable water world’. Thus, they need to be extended further to increase irrigation charges to cover, apart from full O & M costs, at least 50 per cent of the capital cost as well. The electricity pricing for irrigation pumping should be raised to recover the full capital and operating costs and the groundwater extraction charges should be further increased. These financial reforms have to be supplemented by institutional reforms including decentralisation of government agencies associated with the management of water and transfer of irrigation management to farmers through formation of Water Users Associations (WUAs). In the absence of these minimum reforms, sustaining the level of investment envisaged for irrigation development may not be feasible.

<table>
<thead>
<tr>
<th>Table 3.4: Sustaining Irrigation Investment: The Alternative Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business as Usual</strong></td>
</tr>
<tr>
<td>No Change in Surface Water Rates</td>
</tr>
<tr>
<td>No Change in Price of Electricity</td>
</tr>
<tr>
<td>No Groundwater Extraction Charges</td>
</tr>
<tr>
<td>No Institutional Reforms</td>
</tr>
</tbody>
</table>
3.2 LIVELIHOOD SECURITY

3.2.1 Implications for Employment
Investments in irrigation provide huge direct and indirect employment opportunities. While the direct employment opportunities are opened up by the construction of these works, the indirect employment opportunities of a recurring nature are created through improvements in crop husbandry brought about by the conversion of rainfed areas into irrigated areas. Some irrigation projects and their implications for employment are discussed below:

(i) Construction and Maintenance of Irrigation Works
The development of water resources for irrigation provide increased employment opportunities on account of (a) development of surface and groundwater; (b) land formation for irrigated agriculture; and (c) operation and maintenance of irrigation works. While (a) and (b) above, being one time operation, provide direct employment opportunities only for the duration of the work, (c) provides employment opportunities on a continuing basis.

The National Commission on Agriculture (NCA) has estimated that on an average it requires 1.2 man years on construction to provide irrigation to an area of one hectare. The same norm applies to the development of surface water and groundwater. The ratio of skilled to unskilled labour in the construction of irrigation projects has been worked out to be 30:70. On the basis of these norms the irrigation works construction activity is expected to provide employment of the order of between 42 to 61 million man years, depending upon the extent of expansion in irrigated area, by the year 2025. Of this, between 13 to 18 million man years of employment could be that of skilled labour while the remaining 29 to 43 million man years will be for unskilled labour.

Apart from construction activity of irrigation works, complementary land formation works, comprising of construction of water courses, field drains and access roads,
and land leveling and shaping will need to be taken up. The employment potential of these works has been estimated to be about half of that of providing irrigation facilities in the same area. Depending upon the level of expansion in the availability of irrigation, land formation activity is likely to provide employment of the order of between 21 to 31 million manyears by the year 2025. In addition, lining of water courses to minimise seepage losses is also expected to provide considerable employment. The employment generation for this activity has been estimated at one man year for 10 hectares of new irrigated areas. This activity is thus likely to generate between 3.5 to 5.2 million man years of employment.

The operation and maintenance of an irrigation system provides employment on a continuing basis. The available estimates suggest that about 10 persons are employed per thousand hectares of irrigated area in a year. The ratio of skilled to unskilled labour is 40:60. The operation and maintenance of irrigation network is thus likely to generate employment of the order of 0.24 to 0.33 million manyears per year on a continuing basis after the project construction work is completed. Of this employment generated, between 0.10 to 0.14 million manyears of employment will be for skilled labour while the remaining between 0.14 to 0.19 will be for unskilled labour. Unlike the employment generated in construction, which is a one-time employment, employment in operation and maintenance of irrigation works will be available on a perpetual basis.

(ii) Improvements in Crop Husbandry
The introduction of irrigation in an area substantially alters the crop husbandry scenario and enhances the labour requirement as compared to crops grown under dry or rainfed conditions. The additional labour becomes necessary for irrigating the crop, better field preparation, more extensive weeding, application of fertilisers and pesticides and for harvesting the increased produce on account of higher crop yields, its marketing, etc. Also, the total cropped area available, increases because of higher cropping intensity in irrigated areas. Since
these changes in cultivating conditions occur primarily as a result of the availability of irrigation, the difference in labour use under irrigated and rainfed conditions can be attributed principally to irrigation.

Taking into account the likely pace of mechanisation in agricultural operations and the associated skilled labour that this will entail, it has been estimated that on an average 125 mandays per hectare are required for irrigated areas as compared to 80 mandays for rainfed areas. The conversion of rainfed to irrigated conditions thus creates an additional employment of 45 mandays per cropped hectare. The envisaged investments in irrigation and the consequent conversion of rainfed areas into irrigated areas is thus likely to generate additional annual employment of the order of between 5.8 to 8.5 million manyears per year (Table 3.5).

Apart from conversion of rainfed to irrigated areas, some improvements in crop husbandry and technological changes are also likely to take place in the rainfed areas. It has been estimated that these improvements will increase the level of employment in rainfed areas by about 16 mandays per hectare. Such improvements in crop husbandry in dry areas is thus likely to increase employment by between 3.1 to 4.0 million manyears per year.

The changes in crop husbandry activities also has implications for the livestock sector, in that they are likely to intensify the level of livestock activity. The increased livestock activity also offers enormous employment opportunities. Due, however, to lack of empirical evidence on the nature and magnitude of employment generating effects that the interaction between these two activities may cause, estimates of employment effects, though recognised, have not been attempted (Table 3.6).

(iii) Other Employment Effects
Development of irrigation, apart from providing additional employment in construction and through improvements in crop husbandry, forges inter-sectoral and inter-regional
### Table 3.5
Estimated Employment Effects of Additional Irrigation: Construction and Maintenance of Irrigation Works

<table>
<thead>
<tr>
<th></th>
<th>2025 Scenario D1</th>
<th>2025 Scenario D2</th>
<th>2025 Scenario D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition to NIA (mha)</td>
<td>34.9</td>
<td>43.7</td>
<td>51.2</td>
</tr>
<tr>
<td>Employment Generated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Million Manyyears)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Total</td>
<td>41.9</td>
<td>52.5</td>
<td>61.4</td>
</tr>
<tr>
<td>— Skilled</td>
<td>12.6</td>
<td>15.8</td>
<td>18.4</td>
</tr>
<tr>
<td>— Unskilled</td>
<td>29.3</td>
<td>36.7</td>
<td>43.0</td>
</tr>
<tr>
<td>Land Formation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Total</td>
<td>21.0</td>
<td>26.3</td>
<td>30.7</td>
</tr>
<tr>
<td>— Skilled</td>
<td>6.3</td>
<td>7.9</td>
<td>9.2</td>
</tr>
<tr>
<td>— Unskilled</td>
<td>14.7</td>
<td>18.4</td>
<td>21.5</td>
</tr>
<tr>
<td>Lining of Water Courses</td>
<td>3.5</td>
<td>4.4</td>
<td>5.2</td>
</tr>
<tr>
<td>(Total Unskilled)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O&amp;M for Surface Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sources/Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Total</td>
<td>0.24</td>
<td>0.29</td>
<td>0.33</td>
</tr>
<tr>
<td>— Skilled</td>
<td>0.10</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td>— Unskilled</td>
<td>0.14</td>
<td>0.17</td>
<td>0.19</td>
</tr>
</tbody>
</table>

### Table 3.6
Estimated Employment Effects of Additional Irrigation: Improvements in Crop Husbandry

<table>
<thead>
<tr>
<th></th>
<th>2025 Scenario D1</th>
<th>2025 Scenario D2</th>
<th>2025 Scenario D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional GIA (mha)</td>
<td>47</td>
<td>59</td>
<td>69</td>
</tr>
<tr>
<td>Total Rainfed GCA (mha)</td>
<td>92</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>Employment Generated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Million Manyyears/Year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— From Additional GIA</td>
<td>5.8</td>
<td>7.3</td>
<td>8.5</td>
</tr>
<tr>
<td>— From Rainfed Areas</td>
<td>4.0</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>— Total</td>
<td>9.8</td>
<td>10.8</td>
<td>11.6</td>
</tr>
</tbody>
</table>
linkages through output growth and income flows. It has been estimated that irrigation-induced incremental agricultural output valued at Rs. 100 generates Rs. 105 worth of additional output in manufacturing, and Rs. 114 in the tertiary sector, implying an overall non-farm output multiplier of 2.19 (Hazell and Haggblade:1990). This increased activity in other sectors on account of changes in the agriculture sector induced by changes in the irrigation scene have the potential of creating additional employment in these sectors. In addition, sporting and tourism activities, that are likely to increase as a result of increased water resource development, will also generate additional employment.

3.2.2 Impact on Marketed Surplus and Foodgrain Prices
The conversion of rainfed areas to irrigated areas, apart from increasing foodgrain production, is also likely to convert a large number of hitherto subsistence farmers into farmers that produce a net surplus of foodgrains. This surplus foodgrain is expected to enter the markets thereby resulting in substantially increased availability of foodgrains. The increased marketable surplus in turn is expected to keep the market prices under check and make foodgrain available at affordable prices in rural and urban areas.

3.2.3 Impact on Poverty
The inverse relationship between availability of irrigation and incidence of poverty has been demonstrated by a number of researchers (Rao et al.: 1988; Saleth:1997; Bhatia: 1998). It has been found that irrigation is positively associated with the level of per capita consumption expenditure and the proportion of people above the poverty line. The inverse relationship works essentially through the lowering of food prices, as a result of increased production facilitated by the availability of irrigation, which in turn has the effect of increasing the real wages. Expansion of irrigation on such a massive scale is thus likely to contribute significantly to a reduction in the incidence of poverty.
3.2.4 Impact on Income Distribution

The extension of irrigation and the consequent changes in cropping pattern and the increases in crop yields will lead to increases in the income of farming households. It is, however, difficult to assess whether such increases in incomes will improve or worsen the farm income distribution pattern across farms of different sizes under different cultivating conditions. While on-farm benefits from a unit of irrigated area need not necessarily rise with the size of the farm, however, due to possible differences in the use of complementary inputs, such as fertilisers, on different sizes of the farms the benefits from each hectare of irrigated area may increase with the size of the farm. Some available evidence on the introduction of public canal irrigation suggest that availability of irrigation water may lead to a widening of absolute income differentials in the farm sector (Dhawan: 1984). The income differentials between small and big farmers narrow down only in a relative sense, that is, in terms of per cent increase in per capita incomes. Thus, while the rich become richer the poor become less poorer, yet their material standards of living, wealth, etc., become more iniquitous than before. Effective intervention through differential policies directed in favour of small farmers could possibly serve the purpose of reducing relative income differentials in the farm sector, to some extent.

3.2.5 Development of Aquaculture

The availability of irrigation water on such an extensive scale offers widespread opportunities for fresh water aquaculture in conjunction with irrigated agriculture. The practice of aquaculture, besides providing employment, has the potential of substantially raising the farm income. It has been reported that annual average fish production per hectare is around 1642 kg. (Srivastava et al.: 1993). The direct annual average employment from pond operations has been estimated at 158 mandays/ha. Since women perform a large number of operations in the aquaculture production process, aquaculture offers good scope for employment of women. This employment effect of aquaculture will be much larger if one were to take
into account other pond related indirect employment in activities such as pond improvement, pond construction, seed, feed and manure supply, transport, processing and marketing. The all-India average net income per hectare from aquaculture is around Rs. 8000 per hectare (at 1988-89 prices). Widespread promotion of aquaculture will, however, require all round support in terms of input availability and supply, credit and marketing of output.

3.3 WATER FOR HEALTH SECURITY

3.3.1 Diseases Associated with Water

Most of the disease agents that contaminate water and food are biological and originate from animal or human faeces. They include bacteria, viruses, protozoa, and helminths. They are ingested with water or food or conveyed to the mouth by contaminated fingers. Once ingested, most of them multiply in the alimentary tract and are excreted with faeces. Without proper sanitation, they contaminate other water bodies, from where they can again infect other people.

Diseases associated with water can be divided into four groups: water-borne, water-washed, water-based and water-related (WHO: 1992). Water-borne diseases arise from the contamination of water by human or animal faeces or urine infected by pathogenic viruses or bacteria, which are directly transmitted when the water is drunk or used in the preparation of food (e.g. cholera, diarrhoea). Water-washed diseases are due to indirect infection arising from lack of personal hygiene (e.g. trachoma). Specifically, these diseases are caused by scarcity and inaccessibility of water which make washing and personal cleanliness difficult and infrequent. All water-borne diseases are also water-washed diseases. Water-based diseases are caused by ingestion of intermediate host or penetration of wet skin (e.g. schistosomiasis, dracunculiasis). Water-related diseases are caused by insect vectors (e.g. malaria, philarisis, japanese encephalitis).

Water-borne diseases are the largest single category of communicable diseases contributing to infant mortality in
developing countries, and second only to tuberculosis in contributing to adult mortality (WHO: 1992). Among these diseases, diarrhoea is one of the most pressing health problems in developing countries. Among the water-based and water-related diseases, schistosomiasis, dracunculiasis, lymphatic filariasis, and onchocerciasis cause high degree of debilitation in human populations. Of these diseases one that has assumed serious proportions is malaria. The spread of this disease has been facilitated by the extension of perennial irrigation agriculture. The presence of large bodies of water in the vicinity of human dwellings increases the likelihood of infection.

Prevention of water-borne and water-based diseases necessitate an improvement in water quality, while prevention of water-washed diseases require an increase in the availability of safe water. For prevention of water-related diseases, better management of surface water is needed, supplemented by other precautionary measures such as control of mosquitoes.

Though not much data are available on the incidence of diseases associated with water in India, the available information does clearly indicate that such diseases are widespread and prominent. The diseases commonly caused by contaminated water are diarrhoea, trachoma, intestinal worms, hepatitis, etc. About 21 per cent of all communicable diseases in India (11.5 per cent of all diseases) are water-borne diseases (GOI: 1999a, p. 191). According to one estimate, nearly 73 million working mandays are lost every year owing to people falling ill due to water-borne diseases (VHAI: 1997). Diarrhoea, which is the most prevalent water-borne disease, is responsible for 25-30 per cent of deaths in children below five years of age (VHAI: 1997). Also, epidemics of infectious hepatitis (jaundice), food poisoning and typhoid fever are a common occurrence. In addition, there are water-related vector-borne diseases of which malaria is the most prominent. The number of malaria cases in India has ranged from 6.47 million cases and 99 deaths in 1976 to 2.02 million cases and 353 deaths in 1990. In 1995, there were 2.8 million cases and 1061 deaths.
3.3.2 Need for Safe Water and Sanitation

Safe and sufficient water supplies coupled with adequate sanitation would greatly reduce infant and child mortality and prevent a quarter of all diarrhoeal episodes (Esrey et al.: 1990). Increasing the supply of pure water would greatly reduce the incidence of water-washed diseases, and improved sanitation would disrupt the cycle by which the agents of many water-borne and water-based diseases are transmitted to water, food and soil (WHO: 1992). Surveying the literature on the effect of water and sanitation on health, Anderson and Cavendish (1992) come to the conclusion that the provision of improved water supply and sanitation can greatly improve household health, subject to two conditions: first the water made available to household by the projects need to be of the desired quantity and quality; and second, the improvements in health are achieved more consistently when adequate supplies of pure water and sanitation are jointly provided, together with improvements in hygiene. A more recent survey of the literature by Hoddinott (1997) comes to more or less the same conclusion—household sanitation, hygiene practices, and improvement in quality and quantity of water supplied are essential requirements for improving people’s health. It needs to be noted that improvement in only one of these aspects is unlikely to lead to a large reduction in morbidity. Rather, it is the integration all these aspects that would be most effective (Webb and Iskandarani: 1998).

According to WHO’s assessment, improvements in water supply and sanitation can result in 80 to 100 per cent reduction in morbidity in cholera, typhoid, and druncunculosis. Improvements in these areas are expected to reduce morbidity by 60 to 70 per cent in cases of trachoma and shistosomiasis and by 40 to 50 per cent in diseases such as paratyphoid, bacillary, disentery, amoebic disentery, gastroenteritis and diarrhoea (WHO: 1992).

Applying multiple regression analysis to cross-country data, Anderson and Cavendish (1992) have shown that improvements in water supply and sanitation have a
significant effect on infant mortality. The elasticity of infant mortality rate is found to be -0.35, which indicates that if there is a ten per cent increase in the proportion of the population with access to safe water and adequate sanitation, the infant mortality rate will go down by 3.5 per cent.

Figure 1 presents statistical evidence to indicate an inverse relationship between the extent of water supply coverage and morbidity in rural areas in major Indian states, bringing out thereby the significance of safe water supply for reducing water-borne diseases. The rates of morbidity (all diseases) in rural areas (for 1993) for 15 major states have been taken from the study of Gumber (1997). Data on habitations/villages covered with safe water supply (for 1995) have been taken from VHAI (1997). In the graph, water supply coverage is defined as the proportion of habitations/villages covered with safe water supply (partially covered ones are given a weight of 0.5). The correlation coefficient between the rate of morbidity and the percentage of habitations/villages covered with safe water is -0.53, which is statistically significant. This clearly shows that improvements in water supply lead to better health.

The same picture emerges when an inter-state comparison of morbidity is made relating it to the percentage of population covered with safe water (taken from the study of

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**Figure 1**

*Water Supply and Morbidity: Rural India*
Mathur: 1998). The comparison reveals that the morbidity rate is relatively lower for those states which have a relatively higher coverage of the population with safe water. In the bottom five states in terms of access to safe water, the average rate of morbidity is 1622 in rural areas and 1577 in urban areas (per 10,000 population per year). In the top five states, on the other hand, the average rate of morbidity is 1138 in rural areas and 1176 in urban areas. This is again indicative of a significant favourable effect of improvements in water supply on people's health in India.

3.3.3 Water Supply and Sanitation in India

(i) Current Status

Urban water supply and sanitation was accorded due importance from the First to the Fifth Five-Year Plan. The outlay on urban water supply and sanitation increased from Rs 0.43 billion (1.28 per cent of the total public sector outlay) in the First Plan, to Rs 5.49 billion (1.40 per cent) in the Fifth Plan. With the introduction of the Sixth Plan the priority has gradually shifted from water supply and sanitation in urban areas to that in the rural areas. The outlay for rural water supply and sanitation increased from Rs 4.81 billion (1.22 per cent of total public sector outlay) in the Fifth Plan to Rs 107.29 billion (2.47 per cent) in the Eighth Plan. The outlay for urban water supply and sanitation was Rs 59.8 billion in the Eighth Plan (Shukla and Sethuraman: 1999).

The Eighth Plan had sought to increase the coverage of (a) urban population with access to safe drinking water to 94 per cent as against 84 per cent under the Seventh Plan, and (b) urban sanitation from 48 per cent to 69 per cent. The coverage of urban population for drinking water and sanitation, however, could not be raised as planned due to a rapid increase in urban population and inadequate plan outlay (caused by a shift in the priority from urban to rural sector) (GOI: 1996a).

Although the Rural Water Supply Programme and the Minimum Needs Programme were started during the mid-1970s, the Rural Sanitation Programme was initiated only in
the Seventh Plan (1985-90). From 1985-86 to the end of the Eighth Plan (1992-97), a total allocation of Rs. 3.0 billion was made under the Central Rural Sanitation Programme. During the same period, Rs. 4.1 billion was allocated under the Minimum Needs Programme (VHAI: 1997). Of the total plan outlay for rural water supply and sanitation under the Eighth Plan, Rs. 101 billion was for water supply and Rs. 7 billion for sanitation. This reveals that plan outlay for rural sanitation has been meagre as compared to that for rural water supply.

Thanks to the investments made in water supply and sanitation under the various Five-Year Plans, considerable progress has been made in this area. Water supply coverage in rural areas has increased from 30.9 per cent in 1981 to 86.7 per cent in 1997. The coverage in urban areas has increased from 77.8 per cent to 90.6 per cent during the same period. Similarly, there has been a marked increase in coverage of sanitation in urban areas from 26.9 per cent in 1981 to 49.3 per cent in 1997. However, in respect of rural sanitation, the coverage (according to available figures) has remained very low, though it has been increasing during the 1990s. It needs to be pointed out here that the reported official figures on population covered by adequate sanitation facilities in rural areas, shown in the table, relate to only the achievements made through the efforts of the government under certain programmes. While the official figures indicate that only about 6 per cent of the rural population has access to sanitation facilities, the actual coverage is probably much higher. The Ninth Plan document notes that the population coverage by sanitary latrines has increased from 11 per cent to about 16 per cent during the Eighth Plan.

There is considerable variation among the states in regard to the coverage of population by safe water supply and sanitation. The achievements in terms of water supply coverage are relatively high (about 70 per cent or higher) in Gujarat, Haryana, Karnataka, Maharashtra, Punjab and West Bengal, and relatively poor (below 40 per cent) in Kerala and Orissa (Mathur: 1998). There are similar differences in the coverage in respect of sanitation facilities. A survey undertaken by the
National Sample Survey Organisation indicates that the coverage of the population for rural sanitation is relatively low in Bihar and Madhya Pradesh and relatively high in Assam (VHAI: 1997).

In this context, it may be mentioned that the Indian Constitution assigns the responsibility for domestic water supply to state governments. There are differences both within and between states regarding the institutional responsibility for rural and urban water supply. While rural water supply is the responsibility of public works department of the ministries concerned with rural development, the Zila Parishads and Panchayats (local bodies operating at a local level) participate in the provision of water supply and management of rural water works (mainly handpumps; also piped water schemes). The financing of rural water supply is mostly done by budgetary sources. On a small scale, some external agencies such as the UNICEF have supported rural water supply projects (Mathur: 1998).

The responsibility for urban water supply is fragmented between different agencies which include, besides the public health engineering departments of the state governments, state-level parastatal agencies such as water supply and sewerage or drainage boards, city-level water supply and sewerage boards, and local governments. The financing of urban water supply is done by budgetary sources, finances provided by institutions such as the Life Insurance Corporation of India (LIC) and Housing and Urban Development Corporation (HUDCO) and finance provided by external agencies such as the World Bank (Mathur: 1998).

Expenditure on water supply, sewerage and sanitation as a percentage of total expenditure varies significantly among states. According to a study by Mathur (1998) on this subject, it is found that in 1993-94 the relevant ratio was less than 1.5 per cent in Karnataka, Punjab, Uttar Pradesh, and West Bengal, and more than 3 per cent in Madhya Pradesh, Rajasthan and Tamil Nadu. For the aggregate of the 14 states covered in the study, the share of expenditure on water supply, sewerage and
sanitation in total public expenditure during this period was 2.1 per cent.

Having discussed briefly the current status of water supply and sanitation in India, it would be useful to make a comparison with other countries of Asia. In terms of water supply in both urban and rural areas, India compares well with other Asian countries. However, in terms of sanitation facilities in urban areas, India’s performance is inferior to some of the other Asian countries, though the gap is not large. It is in respect of sanitation facilities in rural areas that India’s achievements have been poor. This basically reflects the fact that rural sanitation has remained largely neglected in the Indian plans. It is only from the Seventh Plan that some investments have been made for this purpose. But the amount allocated has been rather small as compared to the requirements.

Creation of the required irrigation infrastructure, apart from contributing to the increased crop yields and providing food security for the ever-increasing population, will also help provide livelihood security to a large section of the increasing population. Investments in irrigation have the potential of creating massive job opportunities in construction of irrigation projects and, once irrigation water is made available, through improved crop husbandry. Improvements in the irrigation and agriculture scenario may induce investments in related activities such as aquaculture, which also has the potential for providing substantial employment opportunities. Through strong multiplier effects these changes will encourage investments in secondary and tertiary sectors as well. These improvements will help raise the level of income of rural households and contribute towards reduction in migration from rural to urban areas. The increases in agricultural production and increased marketed surplus may cause lowering of foodgrain prices in both rural and urban areas. This will help reduce the incidence of poverty. In the following paras we discuss in brief some of these possible implications of changes in the irrigation and agricultural scene for livelihood security.
(ii) Vision of Scenario 2025

Given the current status of water supply and sanitation in India, the problems and inadequacies of the systems, and the efforts being made to remove them, two possible scenarios may be conceived for 2025. Scenario I is the business-as-usual scenario whereby it is assumed that many of the current problems will continue. Scenario II is the sustainable water world scenario where it is assumed that most of the problems will be tackled satisfactorily and sustainable water supply and sanitation systems will be established. Under both Scenario I and Scenario II, complete coverage of the urban and rural population with safe water supply is envisaged. Also, under both scenarios, a reasonable sanitation facility would be available for the entire urban population. But, the differences will be in the quality of various services, in terms of, say, the quantity of water available per person per day. Further, there would be differences in regard to sewerage and sewage, handling of solid waste, sustainability of groundwater, etc. The differences between the two scenarios are spelt out in Table 3.7.

The sustainable water world scenario is attainable, but it requires proper policies, adequate resource mobilisation and considerable efforts directed towards water resource development and management, decentralisation, and people's participation. Policy reforms would be necessary to ensure higher cost recovery and facilitate private sector participation. The elements of strategy for the Ninth Plan for water supply and sanitation outlined above should not remain in paper but become a reality if a sustainable water supply and sanitation system is to be established.

3.3.4 Hydro-power Development

Electricity plays an important role in agriculture sector. Irrigation pump sets energised as on 31st March 1995 were 10.7 million. It has been observed that agriculture remained at second place among the consumers of electricity after industry. Electricity consumption in agriculture increased from 1892 Giga watt hour (GWH) in 1965-66 to 85736 GWH
<table>
<thead>
<tr>
<th>Scenario for Water Supply and Sanitation Facilities, 2025</th>
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<tbody>
<tr>
<td><strong>Scenario I</strong> (business-as-usual)</td>
</tr>
<tr>
<td>Water Supply Coverage</td>
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<tr>
<td>Sanitation Coverage</td>
</tr>
<tr>
<td>- Urban</td>
</tr>
<tr>
<td>- Rural</td>
</tr>
<tr>
<td>Quantity of Water Supplied (lpcd)</td>
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<tr>
<td>- Urban</td>
</tr>
<tr>
<td>- Rural</td>
</tr>
<tr>
<td>Maintenance of Water Supply Systems</td>
</tr>
<tr>
<td>Collection and Treatment of Domestic Sewage in Urban Areas</td>
</tr>
<tr>
<td>Solid Waste Management in Urban Areas</td>
</tr>
<tr>
<td>Cost Recovery</td>
</tr>
<tr>
<td>Private Sector Participation</td>
</tr>
<tr>
<td>Investment</td>
</tr>
<tr>
<td>Sustainability</td>
</tr>
</tbody>
</table>
in 1995-96 which registered an annual growth rate of 13.6 per cent against growth rate of total consumption of electricity of 8.1 per cent. The total power generated in 1994-95 was 350490.4 GWH of which hydro-power generated was 82712.0 GWH, which is less than the electricity consumed by agriculture in 1995-96 i.e. 85736.0 GWH. In other words, the entire hydro-power generated is insufficient to meet the demand of agriculture. The percentage of consumption in agriculture to total consumption has increased from 7 per cent in 1965-66 to 31 per cent in 1995-96. The total installed capacity in 1995-96 was 83287.96 MW of which 20976 MW (25.1 per cent) is hydro-power.

The Central Electricity Authority (CEA) has carried out the re-assessment studies of hydro-electric potential of the country during 1987 and they have assessed the hydro-power potential as 84044 MW at 60 per cent load factor excluding contribution from small schemes. The hydro-potential of 84044 MW at 60 per cent load factor when fully developed would perhaps result in installed capacity of 150,000 MW on the basis of probable average load factor. So far 12700 MW, i.e. less than one-sixth (15.07 per cent) of the country’s total hydro-power potential has been developed and about 6100 MW is being developed.

There are three types of irrigation schemes in the country viz. major, medium and minor schemes. The minor schemes are further divided into two categories viz. surface water and groundwater schemes. The irrigation potential has been estimated at 88.7 million ha at the end of 1995-96. Out of this 32.2 million ha are in major and medium, 12.1 million ha from minor schemes using surface water and 44.4 million ha from minor schemes using groundwater. The ultimate irrigation potential from groundwater schemes is estimated at 64.05 million ha and from minor surface water schemes it is estimated as 17.4 million ha. Thus, it could be seen that another 20 million ha of ground water potential and 5 million ha of minor surface water potential are yet to be harnessed. Some of the minor surface water potential
includes pumping of canal water directly from the rivers, which requires power.

Keeping in view the demands of agriculture especially the needs of the ground water schemes, it is imperative that the hydro-power potential need to be tapped to reduce the import bill of coal & oil, i.e. non-renewable resource energy and also to boost agricultural production.

3.3.5 Water Requirements and Investment Implications
What would be the water requirements for domestic use in the "sustainable water world" scenario? How much investment would have to be made till 2025? These two important questions are taken up in the next section.

In a policy document (GOI: 1999) brought out recently, the National Commission for Integrated Water Resources Development Plan (hereafter, the National Commission) has presented estimates of requirements of water for different uses in the years, 2010, 2025 and 2050. The requirements of water for domestic use have been estimated using alternate population projections and norms for per capita water supply. High water requirement norms are taken as 220 lpcd for urban areas and 100 lpcd for rural areas and low water requirement norms as 165 lpcd for Class I cities, 110 lpcd for other cities/towns and 70 lpcd for rural areas. Two projections have been made for population, which differ in terms of the growth rate of population and the assured rate of increase in urbanisation. One projection is based on the estimates of the United Nations and the other on the estimates of Visaria and Visaria (1996). In the first population projection, total population in 2025 will be 1392 million and the urbanisation ratio 45 per cent and in the second projection, total population will be 1333 million and the urbanisation ratio 37 per cent. Three projections have been made for water requirements for domestic use: (i) a low estimates based on low population projection and low per capita supply norm, (ii) a medium projection based on high population projection but low per capita supply norm and (iii) a high projection based on high population projection and high
per capita supply norm. For 2025, the three projections are 47, 52 and 78 BCM respectively and for 2050, these are 59, 67 and 104 BCM respectively.²

The high per capita water supply norms used by the National Commission are the same as in the "sustainable water world" scenario in Table 3.7. If, for computing water requirements, the low population projection is used instead of the high population projection as done by the Commission, the estimated water requirement comes to 70 BCM. Accordingly, 70 to 78 BCM may be taken as an estimate of the water requirement for domestic use in 2025 in the "sustainable water world" scenario. This would constitute less than 10 per cent of the total requirement of water for all uses in the country in 2025. Since the National Water Policy has accorded top priority to drinking water and the water requirements for household use would constitute only a small part of the available supplies, it seems that the projected water requirement of 70 to 80 BCM will be met.

In the "business-as-usual scenario" the per capita supplies of water will be much lower, as indicated in Table 3.7. For this scenario, the estimated water requirements are 30 to 50 BCM depending on the assumptions about population and per capita supply norms.

Turning to investment implications of the "sustainable water world" scenario, the National Mission on Environmental Health and Sanitation has given estimates for requirements of funds up to 2025 for long-term measures for environmental health and sanitation (reported in GOI: 1996). The estimates, made for different programmes or sub-missions, are: urban low

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2. For 2050, water requirement for domestic use has been estimated also by the India Water Resources Society (IWRS: 1999). This estimate is based on a population projection similar to the high population projection used by the National Commission for Integrated Water Resources Development Plan. Per capita water supply norms have been taken as 200 lpcd for urban areas and 100 lpcd for rural areas. The projection of water requirement for domestic use is 90 BCM which is broadly in line with the projection of the National Commission for Integrated Water Resources Development Plan.
cost sanitation (Rs. 242.8 billion); urban waste-water management which includes sewerage and sewage (Rs. 843.5 billion) and surface drainage (Rs. 272.2 billion); urban solid waste management (Rs. 52.3 billion); rural environmental sanitation (Rs. 385.0 billion); institutional capacity building and human resource development (Rs. 130.9 billion); strengthening of health surveillance and support services (Rs. 11.0 billion); and industrial waste management and air pollution control (Rs. 177.8 billion). Some of these estimates are utilised to work out the investment implications of the “sustainable water world” scenario.

The estimates given above do not cover investment requirements for providing safe water supply to the entire population. This has been estimated as follows: The increase in India’s population between 1997 and 2025 would be about 467 million (from 925 million in 1997 to 1392 million in 2025) and increase in urban and rural population will be 367 million and 100 million respectively. The per capita cost of new schemes for water supply in urban areas is taken as Rs. 1800 and that in rural areas as Rs. 400. The investment requirements, thus, works out to about Rs. 700 billion. An equal amount would probably be necessary for augmentation, rehabilitation etc. of the people already covered by water supply in 1997 (about 815 million persons) as also to meet the cost of shifting from handpumps to piped water systems in rural areas, which is likely to take place in future. Therefore, the investment requirement for water supply for the period, 1997 to 2025, may be placed at about Rs. 1400 billion.

3. The per capita cost of new schemes of water supply is taken as Rs. 1800 for Class I towns (Rs. 1500 in other towns) in the Ninth Plan Working Group Report for Urban Water Supply and Sanitation (GOI: 1996, p. 86). The same figure is adopted here. As regards rural areas, the cost of one handpump is reported as Rs. 30,000 in the Ninth Plan Working Group Report for Rural Water Supply and Sanitation. One handpump is to serve 150 persons. Since in the “sustainable water world” scenario a much higher consumption of water in rural areas is assumed as compared to the present norms, it is assumed that one handpump will serve only 75 persons. Accordingly, the cost per capita is taken as Rs. 400.
Table 3.8 presents an estimate of total investment in water supply and sanitation required for attaining the "sustainable water world" scenario so as to ensure health security of the people by 2025.

The estimated investment requirement shown in Table 3.8 is huge in relation to the plan outlays on water supply and sanitation of Rs 167 billion in the Eighth Plan. Evidently, without private sector participation, such large investments will be difficult to finance.

Table 3.8
Investment Required in Water Supply and Sanitation during 1997-2025 for Scenario II (Sustainable Water World)

<table>
<thead>
<tr>
<th>Item</th>
<th>Investment (Rs. billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supply (urban and rural)</td>
<td>1400.0</td>
</tr>
<tr>
<td>Urban low cost sanitation</td>
<td>284.8</td>
</tr>
<tr>
<td>Sewerage &amp; sewage and surface drainage</td>
<td>1115.7</td>
</tr>
<tr>
<td>Urban solid waste management</td>
<td>52.3</td>
</tr>
<tr>
<td>Rural environmental sanitation</td>
<td>385.0</td>
</tr>
<tr>
<td>Total</td>
<td>3237.8</td>
</tr>
</tbody>
</table>

3.4 ECOLOGICAL SECURITY

3.4.1 India’s Environmental Assets and Their Degradation

Given its geographic, climatic and biological diversity, India has a unique environmental heritage. The land mass of the country and its water bodies sustain an extremely rich variety of plants and animals. The known bio-diversity in India constitutes about 8 per cent of the known global biological diversity. It is one of the twelve mega bio-diversity centres of the world. Currently available data place India in the tenth position in the world in terms of plant variety. In terms of the number of mammalian species, the country ranks tenth, and in terms of the endemic species of higher vertebrates, eleventh (GOI: 1999a, pp. 155-57).

Over the years, there has been considerable environmental degradation in India. Two important dimensions of this
degradation are land/soil degradation and loss of forest area. A large part of the land area in the country shows evidence of degradation. Out of the total geographical area of 329 million hectares, about 175 million hectares are considered degraded, about 141 million hectares are subject to water and wind erosion and another about 34 million hectares are degraded through special factors such as water logging and salinity. As regards forests, India's forest wealth has dwindled significantly over the last five decades—between 1950 and 1980, 4.5 million hectares of forest area has been diverted for non-forestry purposes. Subsequent years have seen a fall in forest area consequent to the increasing diversion of land for other users—the present rate of diversion is about 16 thousand hectares annually. Today, the country's forest cover (of about 63 million hectares) is much below the target specified in the National Forest Policy, 1988, and the dense forest area is only about 60 per cent of the total forest area (GOI: 1999). Among the other important environmental problems in India are pressures on eco-systems and the consequent loss of bio-diversity⁴, air pollution, water pollution, pollution caused by inadequate collection and disposal of solid waste, and coastal and marine pollution.

Development of water resources and the use of water raise important issues connected with ecological security. The eco-systems are affected in three ways: the adverse environmental implications of water resource development projects, the drying up of the rivers, and the adverse effects of water pollution. These are discussed below.

### 3.4.2 Water Resource Development Projects

There has been much criticism of water resource development projects on the ground that they have an adverse impact on the environment (in addition to the large-scale displacement of people that such projects may cause). Water resource development requires large reservoirs which are location

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⁴ According to some estimates, over 1500 plant species are endangered. Also, 79 mammals, 44 birds, 15 reptiles, 3 amphibians and several insects are listed as endangered.
specific. The location of the projects are often in remote areas which have bio-diversity rich forests. Water resource development projects have an adverse impact on environment because they submerge forests, reduce flows in rivers and lead to loss of bio-diversity and degradation of eco-systems.

It needs to be pointed out, however, that an irrigation project normally irrigates an area much larger than the area submerged. The loss of bio-mass through submergence is, therefore, far smaller than the bio-mass generated on account of irrigation. An analysis of 54 projects in India indicates that whereas only 217 thousand hectares of forest land was submerged by the reservoirs of the projects, 13297 thousand hectares of cultivable area was provided with irrigation facility which must have provided more bio-mass than that lost through submergence of forest area (IWRS: 1999). Furthermore, the loss of forest area due to submergence is less than five per cent of the total forest area lost in the last five decades. Notably, it has been observed that a forest far superior to the original one comes up soon after the creation of the reservoir. Evidently, there have been other and more important factors responsible for the loss of forest cover. Moreover, compensatory afforestation is a part of all dam projects, and, if implemented properly, can compensate to some extent for the loss of forest area due to submergence. Similarly, it is possible to take care of the potential loss of flora and fauna due to a reservoir project. Since only a small part of the forest land is submerged, it is not difficult to preserve the endangered species of plants and animals in the vicinity of the project in the same watershed. The submergence of wildlife can be taken care of by relocating the sanctuaries at suitable places and by carrying out wildlife rescue operations, as has been done in some of the projects (IWRS: 1999).

To view water resource development projects as destroyers of eco-systems is not entirely correct. The effects of reservoir projects on ecology is complex. Reservoirs create new conditions for the growth of organisms, and ultimately, as adjustments are made, foster new eco-systems. Moreover, some of the organisms flooded are tolerant to inundation, while others are not. Water current, its levels and temperature and
other characteristics change as a stream is converted to a lake. Within the reservoir, the old stream eco-system is replaced by the new lake eco-system. While this implies a loss of some species, it results in the emergence of some new organisms that may thrive. Below the dam, there may be changes in the organisms within the affected eco-system and loss of diversity and stability as the project leads to changes in the land use pattern (Nigam: 1995, p. 317).

Since water resource development projects can have significant adverse environmental impacts, there are legal and administrative provisions to minimise (or get rid of) these impacts. For all major irrigation, multi-purpose and flood control projects, it is obligatory to get environmental clearance from the Central Ministry of Environment and Forests. The project is considered by the Environmental Appraisal Committee which decides about the acceptance of the project from environmental angle and stipulates environmental safeguards which need to be implemented along with construction activities of the project. The Environment (Protection) Act, 1986, requires the state governments/project authorities to submit environmental impact assessment statements and environment management plans for obtaining clearance for a project. It is also mandatory to get a project's clearance from the forest angle. This can be obtained from a multi-disciplinary environmental committee within the Ministry of Water Resources, constituted in 1990, which oversees the implementation of environmental safeguards stipulated by the Ministry of Environment and Forests while clearing the water resource development project. However, in spite of all these legal and administrative provisions, the implementation of environmental safeguards is often inadequate. This is because the responsibility for implementation rests with the state governments, and in many cases, due care is not taken by the project authorities in this regard (IWRS: 1999, pp. 59-62).

One serious environmental problem caused by irrigation projects is waterlogging and salinity. According to one estimate, at the national level, the problem of waterlogging and salinity
has affected 27 million hectares out of the total geographical area of 329 million hectares. Nearly half of the canal-irrigated area is affected by salt problems to a varying degree. The causes of waterlogging and salinity are: (1) inadequate or lack of artificial drainage and/or restricted natural drainage, and (2) inefficient use of irrigation water.

3.4.3 Minimum Flows in Rivers
Dams create reservoirs to store monsoon flows to be used during the lean season. Uncontrolled extraction of groundwater and direct pumping from the water courses have reduced non-monsoon flows in rivers, and even dried them up, thereby adversely affecting the river eco-systems. Paradoxically, large reservoirs are needed to ensure minimum flows in rivers during the lean season. This requires that low level outlets be provided in new dams, necessitating efforts to provide such outlets in existing dams if technically possible.

3.4.4 Water Pollution
Water pollution is a major environmental concern in India. The main sources of water pollution are discharge of domestic sewage and industrial effluents, which contain organic pollutants, chemicals and heavy metals, and run-off from land-based activities such as agriculture and mining. With the increasing use of fertilisers and pesticides in agriculture, the run-off from irrigated lands has been adding to the water bodies a variety of organic and inorganic pollutants. Further, bathing of animals, washing of cloths and dumping of garbage contribute to water pollution. All these factors have led to pollution of rivers, lakes and coastal area and thus affected the eco-systems. The increasing discharge of domestic and

5. A number of chemical, petrochemical and other industries in the coastal areas have resulted in significant discharge of industrial effluents in the coastal water bodies. Discharge of sewage from large coastal settlements is the other major source of pollution. The water pollution problem in coastal areas is further aggravated by pollutants carried by rivers to the sea. All these upset the coastal and marine eco-systems.
industrial wastes and the use of fertilisers and pesticides in agriculture has also led to the contamination of groundwater at many places making it unfit for human consumption.  

An analysis of water quality during 12 years (1986 to 1997), undertaken by the Central Pollution Control Board (CPCB) has shown that water quality has deteriorated over the years. While Biological Oxygen Demand (BOD) values were below 3 mg/l in 60 per cent of the observations for the period 1986-91, the relevant proportion was 54 per cent in 1994-95. There was a gradual increase in the number of observations, according to which BOD was in excess of 6 mg/l—increasing from 7 per cent of the total observations in 1989 to 16 per cent in 1997 (GOI: 1999a, p. 160).

The data on water quality generated by the CPCB indicate that the mean BOD values have gone up marginally in all the 28 major rivers between 1979 and 1991. These data also reveal a substantial increase in coliform bacteria in the river water during the same period.

An analysis of water quality data for 1997 reveals that in terms of BOD values Kerala is at the bottom and Maharashtra at the top (most polluted). In terms of the presence of coliform bacteria in water, the worst-affected are Uttar Pradesh, Gujarat, Tamil Nadu and Assam. Gujarat tops in chemical pollution, followed by Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Punjab.

(i) Sources of Pollution
An analysis of water quality in some of the Indian rivers during 1996/97 based on data collected by the CPCB indicates that the quality of water in the rivers is generally poor.

Turning to the sources of water pollution, the most important one is the wastewater generated in the cities and

6. A 1994 survey of groundwater quality at 138 sampling locations in 22 industrial zones indicated that the water was unfit for drinking due to high bacteriological and heavy metal contamination (GOI: 1998-99, p. 161).
towns. It was noted above that the treatment of municipal wastewater is woefully inadequate. Some more details may be provided here. Currently, only about 200 cities and towns in India out of a total of 3245 have a sewerage system, and in some of them, it meets their needs only partially. Very few towns have sewage treatment plants, most of which are badly maintained and are often not in working order (VHAI: 1997). A survey conducted in 1988 revealed that 212 class I towns generated 12.1 billion litres of wastewater per day, which was nearly 10 times the wastewater generated in 241 class II cities. Of the wastewater generated in class I cities, 12 metropolitan cities accounted for about 64 per cent. Bombay and Delhi generated more wastewater than that generated in all the class II cities together. Of the wastewater generated in these cities, about 20 per cent was being collected, of which about 80 per cent was receiving primary or both primary and secondary treatment. Of the wastewater generated in class II cities, only 5 per cent was being collected and only 2 per cent was receiving some kind of treatment. In both class I and class II cities, the disposal of wastewater was being done mostly in rivers and agricultural lands.

Discharge of industrial effluents is another major source of water pollution. Some major water polluting industries are fertilisers, refineries, pulp and paper, leather, sugar, distilleries, chemicals, iron and steel, and metal plating. It is noteworthy that a fairly large part, if not the dominant part, of industrial water pollution is caused by small-scale units. The magnitude of the pollution caused by industries may be gauged by the fact that the pollution load of some of the industries is larger than that of a large city. A study on industrial pollution in the late 1970s reported that the pollution from sugar industry alone was more than that of Bombay and Madras put together!

It may be mentioned here that there are strict environmental laws in India which prohibit the discharge of pollutants in water bodies beyond specified standards and lay down penalties for non-compliance. But, for various reasons, it has not been possible to enforce these laws on the industries (specially small-
scale industries) with the consequence that industrial effluents have become a prime source of water pollution. In its Report submitted to the Ministry of Environment and Forests, Government of India, The Task Force which evaluated market-based instruments for industrial pollution abatements has underscored certain deficiencies in the manner in which the rules and regulations for pollution control have been framed. They note that the burden of proof of violating standards is too great and the monitoring procedures (such as the procedure of taking samples) too cumbersome for those rules and regulations to be effectively enforced. They note further that the CPCB and the State Pollution Control Boards (SPCBs) have no real powers to enforce the laws, and the SPCBs are under-staffed and under-funded.

The Task Force has recommended that the current pollution control laws should be amended (or new laws enacted) to allow explicit incorporation of market-based instruments. In the short to medium-term, greater reliance should be placed on economic penalties as in the past. In the long-run, market-based instruments should replace positive provisions in the environmental laws. Some of the other recommendations are: (1) strengthening of monitoring capabilities of the SPCBs, (2) regular monitoring of discharges by firms, and (3) public access to information on (a) discharges by polluters and (b) ambient air and water quality.

Strict environmental laws (command and control measures) or market-based instruments for controlling water pollution can work satisfactorily when applied to large and medium-scale enterprises, provided they are properly implemented. But these measures are unlikely to succeed in the case of small-scale units, for which the cost of compliance is too high. Since there are considerable scale economies in wastewater treatment, Common Effluent Treatment Plants (CETPs) can provide a viable solution to the problem of small-scale industries which

7. It should be noted at the same time that a section of the industry, particularly large firms, has been incurring substantial cost for complying with the environmental regulations.
are not able to bear the cost of treatment of their effluents on an individual basis. This, however, requires collaborative action on the part of small-scale industries and financial assistance by the government. In a bid to provide the benefit of this facility to a large number of small units, a number of CETPs have been set up in the country. Although this has not been a great success, the CETPs have helped in reducing water pollution by small-scale industries.

While some measures have been taken to reduce pollution from specific sources such as cities and industries, non-point pollution from agricultural run-off has not been dealt with. For this purpose, a long-term policy for pesticide use is needed with emphasis on the introduction of environmentally acceptable pesticides and integrated pest management. It is also important to adopt appropriate policies to discourage flood irrigation in areas where chemical fertilisers are extensively used.

(ii) Special Water Cleaning Measures
It may be useful to discuss here briefly some of the special efforts being made by the government to cleanse water bodies. In the mid-1980s Ganga Action Plan (GAP), Phase I, was initiated to cleanse river Ganga. Under this Plan the central government provided funds to the state governments of Bihar, Uttar Pradesh and West Bengal (the states through which the river flows), and to the municipal corporations and towns situated on the banks of the Ganga. The programme started well but slowed down later for various reasons including delays in the release of funds and fund diversion by the state governments. Under the Plan, 261 schemes were sanctioned, which included schemes for sewage interception and diversion (88 schemes), sewage treatment plants (35), low-cost sanitation (43), electric crematoria (28), and river front development (32). Its objective was to reduce the pollution level in the Ganga by at least 75 per cent. As of 1998, total expenditure of about Rs 4.5 billion has been incurred in the implementation of the schemes, and 254 out of 261 schemes have been completed. Capacity to treat 728 MLD of sewage has been commissioned as against the target of 873 MLD of sewage for 25 class I towns along the river.
Thanks to the GAP, there has been a significant improvement in the water quality in the Ganga. Between 1986 and 1998, the BOD values (summer average) in Allahabad and Varanasi (upstream and downstream) have come down from over 10 mg/l to less than 5 mg/l. However, the operation and maintenance of assets created has not been satisfactory in Bihar due to the inability of the state government to provide adequate funds for this purpose. In Uttar Pradesh, the beneficial effect of the GAP is not being fully realised due to inadequate municipal infrastructure for maintaining sewerage systems and erratic power supply, which is affecting the operation of pumping stations, sewage treatment plants, and electric crematoria.

Interception, diversion and treatment of sewage, which has been the main focus of GAP, have brought some benefits to the people in the form of an improvement in river water quality. But what is disturbing is pollution from non-point sources such as disposal of garbage, cattle sheds along the river banks, cattle washing in the river, open defecation along the river banks, and disposal of dead bodies and animal carcasses which continues unabated, thus causing various types of waterborne diseases, especially due to bacterial infection. Unless pollution from these sources is controlled, the full benefits of the GAP cannot be realised.

The second phase of the Ganga Action Plan (GAP-Phase II) envisaged the cleansing of three rivers, Yamuna, Gomati and Damodar. From 1996, GAP-Phase II has been merged with the National River Conservation Plan (NRCP). The expanded NRCP covers 141 towns located along 22 inter-state rivers in 14 states. The total cost of the schemes is Rs. 20.1 billion. During the Eighth Plan, the cost of the schemes is being shared equally by the central government and the concerned state government. In the Ninth Plan, the NRCP has been converted into a fully funded centrally-sponsored scheme. While these efforts of the central government, aimed at conservation of rivers, are laudable, the expenditures being incurred appear rather small in relation to the requirements. Also, there are important questions relating to the state governments' ability to provide adequate funds for the operation and maintenance
of the assets being created and about the control of non-point sources of pollution of rivers.

The National Lake Conservation Plan (NLCP), for the conservation of lakes, is aimed at: (a) prevention of pollution from point and non-point sources, (b) treatment of catchment area, (c) de-silting, and (d) weed-control. Lakes are a part of the water systems and their conservation is important for preserving bio-diversity and ecology. A total of 11 lakes have been identified for an urgent conservation plan on the basis of pollution status and aquatic wealth.

3.4.5 Water for Ecology: Scenario 2025

As in the case of health security, two scenarios can be envisaged for 2025 in regard to ecological security. Scenario I is the business-as-usual scenario, which is based on the assumption that the problem of water pollution will persist, flow in rivers in the lean season will be very small, if at all it is present; and large water resource development projects will continue to be undertaken adversely affecting the environment. On the other hand, Scenario II, the Sustainable Water World scenario, is based on the assumption that the point source pollution of water will be minimised; non-point source of pollution will be contained as far as possible; provision of water will be made for preserving the ecology and environment by providing for afforestation and minimum flows in the rivers; adequate environmental safeguards will be taken in water resource development projects; and there would be greater emphasis on micro-watershed development and water conservation so as to reduce the need for large water resource development projects. The differences between the two scenarios are spelt out in Table 3.9.

To meet the increase in water requirements in the country in the next 25 years, it would be necessary to augment water supplies substantially. This will require that the storage capacities be raised sufficiently, thus necessitating the development of new water resource development projects. Considering the expected increase in demand, the storage capacities may have to be doubled by 2025. The environmental cost that this will entail can be reduced by taking adequate
<table>
<thead>
<tr>
<th>Scenario for Environment and Ecology, 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario I</strong> (Business-as-Usual)</td>
</tr>
<tr>
<td>Water resource development projects</td>
</tr>
<tr>
<td>Many new projects to be undertaken to meet increasing water demand</td>
</tr>
<tr>
<td><strong>Scenario II</strong> (Sustainable Water World)</td>
</tr>
<tr>
<td>New project to be undertaken, but adequate environmental safeguards will be taken; need for large projects to be reduced by depending more on micro watershed development and water conservation; recycling and re-use of water</td>
</tr>
<tr>
<td>Minimum water flow in rivers</td>
</tr>
<tr>
<td>Not ensured; most rivers will become dry or have very little water flow in the lean season</td>
</tr>
<tr>
<td>Minimum flow will be ensured</td>
</tr>
<tr>
<td>Treatment of sewage in urban areas</td>
</tr>
<tr>
<td>Partial</td>
</tr>
<tr>
<td>Complete</td>
</tr>
<tr>
<td>Solid waste management in urban areas</td>
</tr>
<tr>
<td>Partial</td>
</tr>
<tr>
<td>Complete</td>
</tr>
<tr>
<td>Industrial effluents</td>
</tr>
<tr>
<td>Water pollution caused by discharge of industrial effluents will continue; and the problem will become more serious</td>
</tr>
<tr>
<td>Full treatment of industrial effluents; minimum pollution caused</td>
</tr>
<tr>
<td>Non-point pollution (e.g. agricultural run-off)</td>
</tr>
<tr>
<td>Continues unabated</td>
</tr>
<tr>
<td>Contained as far as possible</td>
</tr>
<tr>
<td>Investment</td>
</tr>
<tr>
<td>Resources mobilised far too short compared to requirements</td>
</tr>
<tr>
<td>Adequate investment made; resources mobilised by the government, local organisations and industrial firms</td>
</tr>
<tr>
<td>Sustainability</td>
</tr>
<tr>
<td>Various problems of sustainability encountered</td>
</tr>
<tr>
<td>Water resources are used in a sustainable manner; adequate conservation efforts are made for forests, rivers, and lakes</td>
</tr>
</tbody>
</table>
environmental safeguards, and by relying to a greater extent on micro-watershed development. With growing urbanisation and accelerated industrialisation, the water consumption in the cities and in the industries will increase substantially. Unless facilities for the treatment of domestic sewage and industrial effluents are substantially improved, this would imply a much higher pollution load, leading to great pollution of the water bodies. Scenario II envisages that there will be complete or near complete treatment of industrial effluents and domestic sewage in urban areas. This would also necessitate stronger measures for greater re-cycling and re-use of water. Again, a rapid growth in agriculture and increased use of fertilisers and pesticides is expected in the years to come to feed the growing population. This will further aggravate the pollution problem. Evidently, non-point pollution from agricultural run-off and other sources such as cattle washing in the river will have to be contained. This will require the creation of greater awareness among people about these sources of pollution, as well as policies that will promote less polluting agricultural practices.

The second scenario assumes that there will be provision for water for ecological and environmental requirements. According to the estimates made by the National Commission, in 2025 the water requirement for afforestation will be 67 BCM and that for maintaining a minimum flow in the rivers, 10 BCM. The water requirement for afforestation will be nearly as high as that for domestic and industrial use. Maintaining a minimum flow of rivers will also require expansion of the storage capacity.

Treatment of domestic sewage will entail a large investment as indicated in Table 3.8. To ensure that industrial effluents are properly treated, a large amount of investment will have to be made by industries in effluent treatment plants. It is difficult to give an estimate of the amount of investment that would be necessary, but it is expected to be quite large. To prevent water pollution by small-scale industries, CETPs will have to be set up. This will require financial support from the government. Further, the NRCP and NLCP will have to be strengthened to complete this task satisfactorily, and for this purpose the government will have to mobilise the required resources.
4.1 WATER RESOURCE DEVELOPMENT

The Vision Elements and Key Drivers that have been identified are used to develop two scenarios for 2025. For the Sustainable Water World Scenario, water demands have been estimated to ensure food security, livelihood security, health security and ecological security. The total estimated demand for water (gross) for 2025 is 1027 BCM (see Table 4.1). In order to meet these demands water availability will have to be increased from around 520 BCM in 1997 to more than 1000 BCM in 2025. For meeting the additional demands, investment requirements have been estimated at Rs. 5000 billion during the next twenty-five years or about Rs. 200 billion per year (see Table 4.2).

Such massive investments in new projects should be planned within the framework of integrated river basin development, including flood management. These new projects would enable the transfer of water from surplus to deficit regions as well as during water surplus periods in order to meet its needs during water shortage periods.

However, before such large projects (storage and diversion schemes) are planned and taken-up for execution, a detailed analysis of various options for meeting demands (in each sector) should be made. Such options should include, *inter alia*, the following:

(i) Reconsideration of life styles, development paradigm and attitudes to consumerism;
(ii) Rainfall harvesting for improving soil-moisture content;
(iii) Watershed development;
(iv) Improving water-use efficiency through appropriate technology in irrigation, households and industry;
(v) Recycling and re-use of treated water.

<table>
<thead>
<tr>
<th>Water Demands for 2025 (Gross) (BCM)</th>
</tr>
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<tbody>
<tr>
<td>Irrigation</td>
</tr>
<tr>
<td>Water Supply</td>
</tr>
<tr>
<td>Ecological</td>
</tr>
<tr>
<td>Industry</td>
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<tr>
<td>Energy</td>
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<tr>
<td><strong>Total</strong></td>
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</table>

<table>
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<tr>
<th>Investment Needs: 2000-2025 (Billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
</tr>
<tr>
<td>Water Supply</td>
</tr>
<tr>
<td>Sewage</td>
</tr>
<tr>
<td>Sanitation</td>
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<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Further, development of water resource projects would require explicit consideration of environment and social impacts (e.g. rehabilitation of project-affected people). In this context the issue of trade-off between development and environment should be directly addressed and appropriate decisions taken to harmonise the conflicting points of view and development philosophies.

4.2. POLICY INSTRUMENTS AND INSTITUTIONAL NEEDS

In order to ensure that the vision formulated does not remain merely a theoretical exercise but is also implemented practically, positive action by various stakeholders is required. Some discussions took place on the possible nature of
interventions that could help promote a more sustainable use of available water consistent with the likely demand for the resource. Interventions through appropriate public policies such as rationalisation of water rates, electricity pricing for irrigation pumping, levy of groundwater extraction charges and pollution charges, identification of water user rights, creation of additional storage capacity, including water shed development, for harnessing the rain water, etc. were emphasised by a large number of participants as possible instruments for achieving the desired objectives. Concurrent with these policy interventions appropriate steps need to be initiated to strengthen the water institutions. Private sector participation and involvement of users in managing the water affairs was strongly emphasised. Formation of Water Users' Associations will go a long way in achieving the desired objectives of more efficient and sustainable use of water resources. However, these issues were not discussed in great detail and would be taken up for consideration in the next phase of the India Water Partnership programme.

If no new initiatives are taken and the problems remain as they are, then, given the emerging challenges in terms of a growing population, increasing urbanisation and rapid growth of industries and agriculture, the water scenario for 2025 is one that would involve serious threats to health and ecological security. To avert the crisis situation, it becomes imperative that bold and concerted action is initiated soon. The action will have several components including the following:

- Reform of policies to make possible greater cost recovery and private sector participation;
- Stricter enforcement of environmental laws to ensure control of pollution;
- Mobilisation of sufficient resources to undertake the investments required;
- Adoption of polices for water conservation;
- Initiation of efforts for conservation of rivers, lakes and coastal areas;
• Creation of greater awareness among people about the health and environmental issues;

• Delegation of responsibility for water supply and sanitation to local bodies and creation of greater people's participation in these activities;

• Promotion of agricultural practices that reduce non-point water pollution;

• Adoption of integrated water resource development and management with emphasis on micro-watershed development;

• Establishment of adequate environmental safeguards in water resource development projects.


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Dhawan, B.D. (1988), Irrigation in India’s Agricultural Development, Sage Publications, New Delhi


INCID (1999), *Water for Food and Rural Development-2025*, Indian National Committee on Irrigation and Drainage, New Delhi, Mimeo.


Saleth, R.M. (1997), Farm Technologies and Rural Poverty: An Evaluation of Linkages at the Macro Level, Institute of Economic Growth, Delhi, Mimeo.


# ANNEXURE

INDIA WATER VISION DEVELOPMENT PROCESS - 1999

## Details of Workshops

<table>
<thead>
<tr>
<th>Workshop Place</th>
<th>Date</th>
<th>Organised by</th>
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<tbody>
<tr>
<td>New Delhi</td>
<td>March 10-11</td>
<td>Water &amp; Power Consultancy Services</td>
</tr>
<tr>
<td>New Delhi</td>
<td>May 17-18</td>
<td>Institute for Human Development</td>
</tr>
<tr>
<td>Aurangabad</td>
<td>June 16</td>
<td>Water and Land Management Institute</td>
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<tr>
<td>Chennai</td>
<td>June 18-19</td>
<td>Chairman, Cauvery Technical Cell</td>
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<tr>
<td>Patna</td>
<td>June 21</td>
<td>Centre for Water Resources, Deptt. of Civil Engineering, Patna University</td>
</tr>
<tr>
<td>New Delhi</td>
<td>June 24-25</td>
<td>Institute for Human Development</td>
</tr>
</tbody>
</table>

## Important Background Papers

<table>
<thead>
<tr>
<th>Title of the Paper</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water for Food and Livelihood Security:</td>
<td>R.P.S.Malik and</td>
</tr>
<tr>
<td>A 2025 Vision for India</td>
<td>S.P. Kashyap</td>
</tr>
<tr>
<td>Water for Food and Rural Development 2025</td>
<td>INCID</td>
</tr>
<tr>
<td>Water for Health</td>
<td>S.R. Shukla</td>
</tr>
<tr>
<td>Water for Nature</td>
<td>M.S. Reddy</td>
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<tr>
<td>Water Resource Development Plan of India: Policy and Issues</td>
<td>NCIWRDP</td>
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<td>Water: Vision 2050</td>
<td>IWRS</td>
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</table>
Institutions Involved

Resources and Environment Group, New Delhi
Water and Power Consultancy Services (I) Pvt Ltd, New Delhi
Water and Land Management Institute, Aurangabad
Planning Commission, New Delhi
Ministry of Water Resources, New Delhi
Central Water Commission, New Delhi
Central Groundwater Board, New Delhi
Indian Council of Agricultural Research, New Delhi
Ministry of Urban Affairs, New Delhi
Rajiv Gandhi Drinking Water Mission, New Delhi
Indian National Committee on Irrigation and Drainage, New Delhi
International Commission on Irrigation and Drainage, New Delhi
National Institute of Public Finance and Policy, New Delhi
Centre for Policy Research, New Delhi
Institute of Economic Growth, Delhi
Agricultural Economics Research Centre, University of Delhi
Sardar Patel Institute of Economic and Social Research, Ahemdabad
National Institute of Urban Affairs, New Delhi
National Council of Applied Economics Research, New Delhi
Centre for Water Resources Study, Patna
Anna University, Chennai
Centre for Science and Environment, New Delhi
Development Alternatives, New Delhi
United Nations Development Programme, New Delhi
Water and Sanitation Programme, New Delhi
The World Bank, New Delhi
The Ford Foundation, New Delhi
Department for International Development, New Delhi