Water Policy Issues of India: Study Outcomes and Suggested Policy Interventions

Country Policy Support Programme (CPSP)
Project funded by
Sustainable Economic Development Department
National Policy Environment Division
The Govt. of The Netherlands
(Activity No.WW138714/DDE0014311)

ICID•CIID

INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (ICID)
NEW DELHI

AUGUST 2005
International Commission on Irrigation and Drainage (ICID) was established in 1950 as a Scientific, Technical, Non-commercial, Non-Governmental International Organisation (NGO) with headquarters at New Delhi, India. The Commission is dedicated to enhancing the worldwide supply of food and fiber by improving water and land management, especially the productivity of irrigated and drained lands. The mission of ICID is to stimulate and promote the development and application of the arts, sciences and techniques of engineering, agriculture, economics, ecological and social sciences in managing water and land resources for irrigation, drainage and flood management using research and development, and capacity building. ICID aims to achieve sustainable irrigated agriculture through integrated water resources development and management (IWRDM). ICID network spreads to 104 countries all over the world.

Country Policy Support Programme (CPSP) was launched by ICID in 2002 to contribute to develop effective options for water resources development and management to achieve an acceptable food security level and sustainable rural development. The programme is implemented in five countries viz. China, India, Egypt, Mexico and Pakistan and is funded by Sustainable Economic Development Department, National Policy Environment Division, The Govt. of The Netherlands as Activity No. WW138714/DDE0014311.
ACKNOWLEDGEMENTS

The Country Policy Support Programme was initiated by the International Commission on Irrigation and Drainage (ICID) and funded by Sustainable Economic Development Department, National Policy Environment Division, the Government of The Netherlands.

ICID acknowledges the support it received for the conduct of the studies from many water related International Organisations by way of participation in consultations and dialogues during the different phases of the study. The outcomes were shared with IWMI, FAO, WWF, IUCN and GWP from time to time. Their suggestions and appreciation are gratefully acknowledged.

ICID acknowledges the guidance and support received from President Keizrul bin Abdullah and President Honoraire Dr. Bart Schultz. The initiative of Dr. C D Thatte, Secretary General Honoraire enabled us to start the project in 2002, which he pioneered untiringly till his relinquishment of the office of Secretary General in December, 2003.

ICID identified and assigned the task of water assessment studies to the Indian Association of Hydrologists (IAH). A team comprising Mr. A D Mohile, former Chairman, Central Water Commission, Mr. L N Gupta, former Executive Director WAPCOS contributed for the development of Basin-wide Holistic Integrated Water Assessment (BHIWA) Model and its application to the Indian and Chinese river basins. Their support in evolving the model and its application was valuable. The sharing of data and knowledge of Sabarmati and Brahmani basin, by the Gujarat Government (Water Resources Dept.) and Orissa Government (Water Resources Dept.) and Central Water Commission (CWC) helped ICID to examine meaningful scenarios of the above two basins. Their contributions are duly acknowledged. A review by Dr. P.B.S. Sarma, former Director, Water Technology Center, IARI also helped in the editing task. At the central office, ICID, Dr. S A Kulkarni, Director (I) ably coordinated the execution of various CPSP activities since its inception and prepared the report for printing. Their contributions are duly acknowledged.

ICID acknowledges the donors for their confidence in ICID in assigning the task of exploring strategic direction for addressing water needs of all sectors in an integrated manner, keeping rural development as one of the key drivers.

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August, 2005
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### ACRONYMS / ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>B as U</td>
<td>Business As Usual</td>
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<tr>
<td>BHIWA</td>
<td>Basin Wide Holistic Integrated Water Assessment</td>
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<tr>
<td>BCM</td>
<td>Billion (10^9) Cubic Meters = 10^3 MCM = 1Km^3</td>
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<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
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<td>CCA</td>
<td>Culturable Command Area</td>
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<td>CGWB</td>
<td>Central Ground Water Board</td>
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<td>CPCB</td>
<td>Central Pollution Control Board</td>
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<td>CFSP</td>
<td>Country Policy Support Programme</td>
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<td>CNCID</td>
<td>Chinese National Committee on Irrigation and Drainage</td>
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<td>CWC</td>
<td>Central Water Commission</td>
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<td>D&amp;I</td>
<td>Domestic and Industrial</td>
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<td>DJB</td>
<td>Delhi Jal Board (Delhi Water Board)</td>
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<td>DWFE</td>
<td>Dialogue on Food, Water and the Environment</td>
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<td>EFR</td>
<td>Environmental Flow Requirement</td>
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<td>ET</td>
<td>Evapo-Transpiration</td>
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<td>FAO</td>
<td>Food and Agriculture Organisation of United Nations</td>
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<td>GDP</td>
<td>Gross Domestic Products</td>
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<td>GIA</td>
<td>Gross Irrigated Area</td>
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<td>GIDC</td>
<td>Gujarat Industrial Development Corporation</td>
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<td>GOI</td>
<td>Government of India</td>
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<td>GW</td>
<td>Ground Water</td>
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<td>GWP</td>
<td>Global Water Partnership</td>
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<td>Ha/ha</td>
<td>Hectare</td>
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<td>IAH</td>
<td>Indian Association of Hydrologists</td>
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<td>ICID</td>
<td>International Commission on Irrigation and Drainage</td>
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<td>IFFCO</td>
<td>Indian Farmers Fertilizer Cooperative</td>
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<td>IFFRI</td>
<td>International Food Policy Research Institute</td>
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<tr>
<td>INCID</td>
<td>Indian National Committee on Irrigation and Drainage</td>
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<td>IPTRID</td>
<td>International Programme for Technology and Research on Irrigation and Drainage</td>
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<td>IWMI</td>
<td>International Water Management Institute</td>
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<td>IWP</td>
<td>India Water Partnership</td>
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<td>IWRDM</td>
<td>Integrated Water Resources Development and Management</td>
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<td>IUCN</td>
<td>The World Conservation Union</td>
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<tr>
<td>Km</td>
<td>Kilometer</td>
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<tr>
<td>lpcd</td>
<td>Liters Per Capita Per Day</td>
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<tr>
<td>MAR</td>
<td>Mean Annual Runoff</td>
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<tr>
<td>MCM</td>
<td>Million Cubic Meter</td>
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<tr>
<td>MFN</td>
<td>Minimum Flow Needs</td>
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<tr>
<td>Mha</td>
<td>Million hectares</td>
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<tr>
<td>Mld</td>
<td>Million liters per day</td>
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<tr>
<td>MoA</td>
<td>Ministry of Agriculture</td>
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<td>MoEF</td>
<td>Ministry of Environment and Forests</td>
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<td>MoRD</td>
<td>Ministry of Rural Development</td>
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<td>MoTA</td>
<td>Ministry of Tribal Affairs</td>
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<td>MoWR</td>
<td>Ministry of Water Resources</td>
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<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>NAP</td>
<td>National Agriculture Policy, Government of India</td>
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<td>NALCO</td>
<td>National Aluminum Company</td>
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<td>NCIWRDP</td>
<td>National Commission on Integrated Water Resources Development Plan</td>
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<td>NEP</td>
<td>National Environment Policy</td>
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<td>NEERI</td>
<td>National Environmental Engineering Research Institute</td>
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<tr>
<td>NGO</td>
<td>Non Governmental Organisation</td>
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<td>NIA</td>
<td>Net Irrigated Area</td>
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<td>NIH</td>
<td>National Institute of Hydrology</td>
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<td>NSA</td>
<td>Net Sown Area</td>
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<td>NTPC</td>
<td>National Thermal Power Corporation</td>
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<td>NWDPRA</td>
<td>National Water Development Programme for Rural Areas</td>
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<td>NWP</td>
<td>National Water Policy</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<td>RWA</td>
<td>Residents Welfare Association</td>
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<tr>
<td>SB</td>
<td>Sub-Basin</td>
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<tr>
<td>SOPPECOM</td>
<td>Society for Promoting Participative Eco System Management</td>
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<tr>
<td>SW</td>
<td>Surface Water</td>
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<tr>
<td>t/ha</td>
<td>Tons per hectare</td>
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<td>ULB</td>
<td>Urban Local Body</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<td>UNICEF</td>
<td>United Nations International Children Education Fund</td>
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<td>UWSS</td>
<td>Urban Water Supply and Sanitation</td>
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<td>WAPCOS</td>
<td>Water and Power Consultancy Services (I) Ltd.</td>
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<td>WATERSim</td>
<td>Water, Agriculture, Technology, Environment and Resources Simulation Model</td>
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<td>WFFRD</td>
<td>Water For Food and Rural Development</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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<td>WSI</td>
<td>Water Situation (Scarcity) Indicator</td>
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<td>WUA</td>
<td>Water Users Association</td>
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<td>WWC</td>
<td>World Water Council</td>
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<td>WWF</td>
<td>World Wide Fund for Nature</td>
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<td>WRDP</td>
<td>Water Resources Development Plan</td>
</tr>
<tr>
<td>WSM&amp;D</td>
<td>Watershed management &amp; Development</td>
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</tbody>
</table>
# CONTENTS

| ACKNOWLEDGEMENTS | iii |
| CONTRIBUTORS | iv |
| ACRONYMS / ABBREVIATIONS | v |
| EXECUTIVE SUMMARY | x |

## CHAPTER 1  INTRODUCTION  1-2
1.1 Background to Country Policy Support Programme (CPSP)  1
1.2 Structure of the Report  1

## CHAPTER 2  STATE OF WATER RESOURCES IN INDIA  3-14
2.0 Land use  3
2.1 Water Resources  3
2.2 Population and food security  8
2.3 Water for Food  8
2.4 Water for People  10
2.5 Water for Nature  12
2.6 Total Water Requirement  12
2.7 Water Quality  13
2.8 Institutional Framework for Water Resources Development  13

## CHAPTER 3  PREVAILING POLICIES AND VISION FOR INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT  15-18
3.0 Introduction  15
3.1 National Water Policy (2002)  15
3.2 National Agriculture Policy (2000)  15
3.4 National Policy on Tribals  17
3.6 India Water Vision 2025 framed by India Water Partnership (2000)  18
3.7 Notes on New Policy Initiatives on Environments and Tribal Affairs  18

## CHAPTER 4  WATER ASSESSMENT OF SELECTED BASINS AND EXTRAPOLATION TO OTHER INDIAN BASINS  19-30
4.0 Introduction  19
4.1 Modelling Framework  19
4.2 Assessments for the Selected River Basins ................................................................. 20
4.3 Extrapolation to Other Indian Basins ........................................................................ 26

CHAPTER 5 POLICY ISSUES EMERGING FROM ASSESSMENTS ......................... 31-40

ANNEXURES .............................................................................................................. 41-84
Annexure-1 Some Common Issues Related to Water Supply and Sanitation ............. 41
Annexure-2 Water Supply Status in Selected Cities in India ........................................ 43
Annexure-3 National Water Policy (April 2002) ............................................................. 49
Annexure-3 a Extracts from National Agriculture Policy (2000) ............................... 56
Annexure-5 Extracts from the Press Note dated 19 May 2005 of the Ministry of Tribal Affairs (MoTA) ........................................................................................................ 65
Annexure-6 Extracts from India Water Vision, 2025 framed by IWP ........................... 67
Annexure-7 Workshops, National Consultations and Disseminations of the Study Components and Model Developed Under CPSP Programme ........................................... 68
Annexure-8 Indian National Consultation-Country Policy Support Programme (INC-CPSP), Agencies and Experts who joined the Consultation Process .................................. 71
Annexure-8a Indian National Consultation-Country Policy Support Programme (INC-CPSP), 21-22 November 2003, Suggestions and Comments Received at the Consultation .......... 74

REFERENCES ............................................................................................................. 79
EXPLANATORY NOTES / GLOSSARY ................................................................. 80-84
LIST OF FIGURES

Figure 1: River Basins of India 4
Figure 2: Schematic Diagram of BHIWA Model 20
Figure 3: Location of the Sabarmati and Brahmani River Basins 21
Figure 4: Map of Sabarmati River Basin 22
Figure 5: Map of Brahmani River Basin 23

LIST OF TABLES

Table 1: Land Use Pattern in India 3
Table 2: Drainage Areas of the Indian River Basins 5
Table 3: India’s Basin-wise Mean Annual Water Resources and Utilisable Potential 6
Table 4: Water Demand for Various Sectors in 1998 and 2025 in India 13
Table 5: Ministries/Department of GOI dealing with subject of water and related issues 14
Table 6: Consumptive use (ET) by Different Use Sectors in Sabarmati Basin 25
Table 7: Monthly River Flows in Different Scenarios in Sabarmati Basin 25
Table 8: Consumptive use (ET) by Different Use Sectors in Brahmani Basin 27
Table 9: Monthly River Flows in Different Scenarios in Brahmani Basin 27
Table 10: Grouping of River Basins by Water Situation Indicators 29
Table 11: Water Balance of a Typical 1 km² Low Rainfall Rural Area in India 35
Table 12: Estimate of Per Capita Income from Typical 1 km² Low Rainfall Rural Area in India 36
Table 13: Assumptions from Computation of Income in Table 12 36
The World Water Vision on *Water for Food and Rural Development* (WFFRD) for year 2025, formulated through extensive consultations held in over 43 countries, was facilitated by International Commission on Irrigation and Drainage (ICID) and a few other International Organisations. The theme document presented at the 2nd World Water Forum in The Hague in 2000 projected a substantial increase in the global water withdrawal, water storage and irrigation expansion for the pre-dominant “food sector”. (largely consumptive). A majority of these projections of large increases related to the developing countries. However, the integrated overview Water Vision document scaled down these requirements in an attempt to consolidate conclusions and recommendations of various other themes. It also did not reflect quantification of water needs for the “people sector” (largely non-consumptive) and the “nature sector”.

In order to analyse the supply and demand issues of all the three sectors, namely food, people and nature in an integrated manner, ICID initiated a ‘Strategy for Implementation of Sector Vision on Water for Food and Rural Development’ initiative in the year 2000. ICID also felt the need to mobilise strong international support for strategies and policies in water sector to achieve food security and reduce poverty in developing countries through independent water assessments. In line with this, ICID launched a project titled “Country Policy Support Programme (CPSP)”, with a funding support from the Government of The Netherlands.

China, Egypt, India, Mexico and Pakistan having 43% of the world population and 51% of the world irrigated areas were chosen as participating countries in the CPSP. To begin with, detailed assessments were planned and implemented for the selected sample basins for the two most populous countries of the world, viz.; China and India considering their population growth and rate of urbanisation which factors have strong bearing on water demands. Multi-stakeholder consultations at the respective basins and national level were held to discuss the outcome of detailed assessments, including extrapolation to country level and findings from such consultations were used to identify elements in the national policies requiring changes in the context of integrated and sustainable use of this vital natural resource. This experience in assessments was to be used for a similar exercise at a lesser scale in the remaining three participating countries.

For carrying out detailed water assessment in India, a water deficit basin in the west coast, namely the Sabarmati river basin, a water rich basin in the east coast, namely the Brahmani river basin were chosen. A Basin-wide Holistic Integrated Water Assessment (BHIWA) model evolved by ICID has been applied to these two basins. The results of the assessment for these two basins, extrapolation of the assessment and policy related issues highlighted by the studies were presented in a National Consultation held in November 2003, at New Delhi. The present report examines the water and related policies that have been evolved through both the basin studies.

The geographical area of India is 329 Mha of which is 180.6 Mha is arable. A total area of 142 Mha is net sown area, of which 57 Mha is irrigated area. India has the largest irrigated area in the world. The total drainage area of India is divided into 24 basins of which 13 major basins have a drainage area more than 20,000 km². The average annual renewable water resources of the country is assessed as 1953 billion cubic meters under pseudo natural conditions by the National Commission for Integrated Water Resources Development Plan (NCIWRDP, 1999). The potentially utilisable water resources is estimated at 1086 billion cubic meters, (690 billion cubic meters from surface water and 396 billion cubic meters from groundwater).

The present (2001) population of the country is 1027 million, which is projected to increase in 2025 to 1333 million (higher limit). The per capita availability of water, which in 2001 was 1901 cubic meter per year, considering the population of 1027 million and renewable water resources as 1953 billion cubic meters, it will reduce to 1518 cubic meters with the projected population of 1333 million in 2025. The present water withdrawals are assumed by NCIWRDP (1999) as 629 billion cubic meters and in 2025 are projected to grow further and are expected to be 843 billion cubic meters, considering the growth of population, urbanisation and industry. The existing live
storage capacity of major and medium storage dams is only about 177 billion cubic meters. The ultimate irrigation potential has been assessed as 140 Mha of which about 100 Mha has been created so far. Further expansion of irrigation potential will require an increase of roughly 100 billion cubic meters in the total live storage capacity.

At present, apart from Ministry of Water Resources, the Ministries of Agriculture, Rural Development, Urban Development, Forest and Environment, Shipping, Power, Industrial Development and Energy are involved in the Management of Water Resources in some form or other. The Water Policies are covered in the National Water Policy 2002. Besides these are also directly/indirectly influenced by policies to their use sector viz; the National Agricultural Policy 2000, The National Environment Policy (Draft, 2005). The National Water Policy and extracts from other sector policies (see Annexures) have been examined. In addition, the MoWR and India Water Partnership (IWP) have prepared their vision documents for Integrated Water Resource Development. These are also briefly covered in this report.

BHIWA model developed for assessment of water resources at the basin level and two sample river basins namely - Sabarmati and Brahmani basins are briefly described in the report. The sample basin results were extrapolated to other basins of India. Policy interventions emerging from the studies in the context of integrated and sustainable water use have been evaluated in the report.

A summary of the key policy issues emerging from the detailed assessments and consultations held at basin/national level is as follows:

- To account for direct evapo-transpiration from rainfall and soil moisture, it is essential that precipitation (or rainfall), which forms the primary source of all waters on land, rather than the terrestrial surface and ground water runoff is to be recognised as the primary and real resource for water assessments.
- There is also the need for accounting of additional water availability due to return flows; and accounting of water withdrawals and consumptive use by sectors, separately and collectively towards an integrated and sustainable water management.
- The consumptive use, which results in the depletion of resource, needs to be managed through increases in efficiencies across all sectoral uses, and by curtailing specially its “non-beneficial” component of evapo-transpiration both from lands under natural use and from lands under agricultural use.
- While local harvesting of rain can to some extent be promoted, its usefulness in water short basins, where the existing reservoirs hardly fill up, is very limited as it impacts negatively on the filling of existing storages on the main river and its tributaries.
- Integration of land and water uses is necessary. In irrigation projects, where all lands cannot be irrigated in all seasons due to water availability and other constraints, rain-fed agriculture needs to be integrated in the cropping patterns.
- Integrating of land, water and livelihoods is necessary. In many low rainfall and water short areas, with considerable rural population. This rural population has to obtain much of the income from the land. Irrigation may be a viable option for increasing their income levels, and for alleviating poverty. Similarly, tribal population settled in forests, which, according to the emerging policy initiative, would obtain some land rights for cultivating small patches in the forests. These lands may have low productivity. Water use, through watershed management or irrigation may provide them with some additional income, and alleviate poverty.
- Inter-basin transfer of surface waters from adjacent river basin or basins is an obvious option to meet the additional needs of water deficit basins such as Sabarmati and to restore the groundwater regime and provide for environmental flows in the downstream.
- Inter-basin transfers, in the water short basins with considerable rural population, appear necessary to increase the economic carrying capacity of the basin, through increased income from the small landholdings.
- The high groundwater use, which has developed in many water-short basins, needs to be curtailed
as artificial recharge from imported water may be technically and economically unviable, besides threatening water quality and reducing dry season river flows.

- For water short basins, a better soil and water management through introduction of sprinkler and micro irrigations etc. would no doubt be of some help in demand management. But likely growth of irrigation and D&I demands in future dictate much larger imports from outside basins in future. As mentioned earlier, this is also needed to restore the dry season flow in the vulnerable reaches and improve freshwater environment especially in the lower reaches of the rivers like Sabarmati.

- The increasing hazards of pollution of surface and ground waters, through higher proportion of return flows, needs to be countered both by adequate treatment of the wastewater being discharged into natural waters, and by encouraging reuse of wastewaters without discharging these in water bodies.

- The use of good quality stored water, for dilution of wastewaters, appears a costly solution, which ties up the precious water resource. Adequate treatment of wastewaters, recycling and reuse appear to be the more efficient options. But even then, in a few industrialised zones having large potential for accidental pollution hazards, some stored water can be kept reserved for dilution, as an emergency measures.

- In some water-rich basins, the groundwater use are not developing beyond that required for meeting domestic demands of the rural areas. The growing use of surface water for irrigation is likely to increase the returns to the groundwater, and the consequent regime changes in groundwater can lead to waterlogging. A balanced, conjunctive use of both the sources is essential for avoiding such hazards. Policies, which encourage the farmers to use the ground-waters, in preference to the cheaper public canal water, need to be put in place in such situations.

- Adjusting the cropping patterns to the availability of water, through a shift from post monsoon irrigation to monsoon irrigation, can reduce the consumptive use of water.

- The high priority given to the drinking water has to be elaborated by defining the core and non-core demands, and by allocating the better quality and more reliable sources to meet the core demand.

- The development of urban water supply needs to be done along with the development of sewerage and sewage treatment. A mandatory provision, which does not allow the public funding of only the supply part, would be of help.

- Recycling of water within the domestic use would reduce the demand on good quality raw water, and this needs to be encouraged in water short areas. Similarly, as stated, reuse of domestic wastes in irrigation would improve the quality of river waters.

- A periodic review of supply norms, in regard to domestic water, is necessary. In the long run, the disparity between urban and rural users needs to be diminished, by providing piped household connection and flush toilets, in the rural areas.

- Environmental water requirements need to include both the requirements (mostly consumptive) of the terrestrial eco-systems, as also the flow requirement (EFR) of the aquatic ecosystems. While environmental flow requirements (EFR) need to be recognised as valued requirements, acceptable methods (which consider the water regimes required by the different species, as also the tradeoffs, as preferred by the society, between the environmental and other uses), need to be developed.

- Navigational use is many times compatible with the environmental flow requirements. However, where the navigational flow requirements in some months are more than EFR, the trade-offs between navigation and other uses would have to be considered, and the basin water management may have to be adjusted to meet the accepted navigational requirements.
1.1 Background to Country Policy Support Programme (CPSP)

The World Water Vision on Water for Food and Rural Development (WFFRD) for year 2025, formulated through extensive consultations held in over 43 countries, was facilitated by International Commission on Irrigation and Drainage (ICID) and a few other International Organisations. The theme document presented at the 2nd World Water Forum in The Hague in 2000 projected a substantial increase in the global water withdrawal, water storage and irrigation expansion for the pre-dominant “food sector”. (largely consumptive). A majority of these projections of large increases related to the developing countries. However, the integrated overview Water Vision Document scaled down these requirements in an attempt to consolidate conclusions and recommendation of various other themes. It also did not reflect quantification of water needs for the “people sector” (largely non-consumptive) and the “nature sector”. Water needs of the food sector depend on the population, the changing dietary preferences and the income levels. Likewise, the water needs of the people sector also depend, apart from population, on the quality of life, income levels and the general economic growth including the industrial growth. The water needs of the nature sector, including the need of the terrestrial and aquatic eco-systems depend on the land use as also on the preferences of the society in trade offs between the uses and ‘non-use’ of water.

In order to analyse the supply and demand issues of all the three sectors, namely food, people and nature in an integrated manner, ICID initiated a ‘Strategy for Implementation of Sector Vision on Water for Food and Rural Development’ initiative in the year 2000. ICID also felt the need to mobilise strong international support for strategies and policies in water sector to achieve food security and reduce poverty in developing countries through independent water assessments. In line with this, ICID launched a project titled “Country Policy Support Programme (CPSP)”, with a funding support from the Government of The Netherlands.

China, Egypt, India, Mexico and Pakistan having 43% of the world population and 51% of the world irrigated areas were chosen as participating countries in the CPSP. To begin with, detailed assessments were planned and implemented for the selected sample basins for the two most populous countries of the world, viz.; China and India considering their population growth and rate of urbanisation which factors have strong bearing on water demands. Multi-stakeholder consultations at the respective basins and national level, were held to discuss the outcome of detailed assessments, including extrapolation to country level and findings from such consultations were used to identify elements in the national policies requiring changes in the context of integrated and sustainable use of this vital natural resource. This experience in assessments was to be used for a similar exercise at a lesser scale in the remaining three countries.

1.2 Structure of the Report

This report deals with water policy issues of India and contains 5 chapters. Chapter 2 describes the state of water resources in India, covering river basins, estimates of ‘natural’ water resources, estimates of present and future population, water requirement for irrigation, and for domestic and industrial use and nature sector (terrestrial and aquatic eco-system needs). Chapter 3 on Policy and Vision for Integrated Water Resources Development and Management covers water policies contained in National Water Policy, besides
relevant extracts from National Agricultural Policy, National Environment Policy, the vision of GOI for Integrated Water Resources Development and Management (IWRDM), and India Water Vision 2025 of India Water Partnership (IWP) are also briefly covered. Certain new initiatives of Government of India (GoI), regarding tribal development etc., which can influence the water-related policies, are also discussed. Chapter 4 outlines water resources assessment studies of two selected basins in India. It includes the projection of the water scenarios for these basins for the past, present and alternative future scenarios. Through the application of the BHIWA model, especially developed to make water assessments more broad based and holistic. The Chapter 5 then discusses some of the important policy issues resulting from these assessments and consultation process.
2.0 Land use

Indian peninsula is located in the northern hemisphere between latitudes 8° 4’N and 37° 6’N and longitudes 68° 7’E and 97° 25’E. Pakistan, China, Nepal, Bhutan, Myanmar and Bangladesh share common boundaries with India.

The geographical area of the country is 329 million hectares (Mha). Out of this the reporting area is 305 Mha. The distribution of agricultural land by use in India for the year 1999-2000 is given in Table 1 (MOA, 2003).

A total area of 141.2 Mha is net sown area. It has remained stagnant over the past three decades and it is not possible to increase it further. The present net irrigated area is 57 Mha and the remaining area (84 Mha) is rainfed.

2.1 Water Resources

The geographical area of India has been divided into 24 basins (Figure 1). The catchment/ drainage areas of these basins are given in Table 2 (MOWR, 1999 a).

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Classification</th>
<th>Area (Mha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Geographical area</td>
<td>328.73</td>
</tr>
<tr>
<td>II.</td>
<td>Reporting area for land utilisation statistics</td>
<td>306.05</td>
</tr>
<tr>
<td>1.</td>
<td>Forest</td>
<td>69.02 (22.6)</td>
</tr>
<tr>
<td>2.</td>
<td>Not available for cultivation (A+B)</td>
<td>42.41 (13.8)</td>
</tr>
<tr>
<td>(A)</td>
<td>Area under non agricultural uses</td>
<td>22.97 (7.5)</td>
</tr>
<tr>
<td>(B)</td>
<td>Barren and unculturable land</td>
<td>19.44 (6.4)</td>
</tr>
<tr>
<td>3.</td>
<td>Other uncultivated land excluding fallow land (a+b+c)</td>
<td>28.49 (9.3)</td>
</tr>
<tr>
<td>(a)</td>
<td>Permanent pastures and other grazing lands</td>
<td>11.04 (3.6)</td>
</tr>
<tr>
<td>(b)</td>
<td>Land under miscellaneous tree crops and groves not included in net area sown</td>
<td>3.62 (1.2)</td>
</tr>
<tr>
<td>(c)</td>
<td>Culturable waste land</td>
<td>13.83 (4.5)</td>
</tr>
<tr>
<td>4.</td>
<td>Fallow lands (i+ii)</td>
<td>24.91 (8.1)</td>
</tr>
<tr>
<td>(i)</td>
<td>Fallow land other than current fallows</td>
<td>10.11 (3.3)</td>
</tr>
<tr>
<td>(ii)</td>
<td>Current fallows</td>
<td>14.80 (4.8)</td>
</tr>
<tr>
<td>5.</td>
<td>Total cropped area (Gross sown area)</td>
<td>189.74</td>
</tr>
<tr>
<td>6.</td>
<td>Area sown more than once</td>
<td>48.51</td>
</tr>
<tr>
<td>7.</td>
<td>Net sown area (5-6)</td>
<td>141.23 (46.1)</td>
</tr>
<tr>
<td>III.</td>
<td>Net irrigated area</td>
<td>57.24 (18.7)</td>
</tr>
<tr>
<td>IV.</td>
<td>Gross irrigated area</td>
<td>76.34</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses indicate percentage of the reported area.

Table 1. Land Use Pattern in India
Figure 1 River Basins of India

1. Indus
2. Ganga
3. Brahmaputra
4. Subarnarekha
5. Brahmani-Baitarani
6. Mahanadi
7. Godavari
8. Krishna
9. Pennar
10. Cauvery
11. Tapi
12. Narmada
13. Mahi
14. Sabarmati
15. West Flowing Rivers of Kachchh and Saurashtra Including Luni.
16. West Flowing Rivers South of Tapi.
17. East Flowing Rivers between Mahanadi and Godavari
18. East Flowing River between Godavari and Krishna
19. East Flowing Rivers between Krishna and Pennar
20. East Flowing Rivers between Pennar and Cauvery
21. East Flowing Rivers South of Cauvery
22. Area of North Ladakh Not draining into Indus
23. Rivers draining into Bangladesh
24. Rivers draining into Mayanmar
25. Drainage Area of Andaman and Nicobar and Lakshadweep
### Table 2.

**Drainage Areas of the Indian River Basins**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Name of the river basin</th>
<th>Basin area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indus</td>
<td>321,289</td>
</tr>
<tr>
<td>2a</td>
<td>Ganga sub basin</td>
<td>862,769</td>
</tr>
<tr>
<td>2b</td>
<td>Brahmaputra sub basin</td>
<td>197,316</td>
</tr>
<tr>
<td>2c</td>
<td>Meghna sub basin</td>
<td>41,157</td>
</tr>
<tr>
<td>3</td>
<td>Subernarekha</td>
<td>29196</td>
</tr>
<tr>
<td>4</td>
<td>Brahmani-Baitarani</td>
<td>51,822</td>
</tr>
<tr>
<td>5</td>
<td>Mahanadi</td>
<td>141,589</td>
</tr>
<tr>
<td>6</td>
<td>Godavari</td>
<td>312,812</td>
</tr>
<tr>
<td>7</td>
<td>Krishna</td>
<td>258,948</td>
</tr>
<tr>
<td>8</td>
<td>Pennar</td>
<td>55,213</td>
</tr>
<tr>
<td>9</td>
<td>Cauvery</td>
<td>87,900</td>
</tr>
<tr>
<td>10</td>
<td>Tapi</td>
<td>65,145</td>
</tr>
<tr>
<td>11</td>
<td>Narmada</td>
<td>98,796</td>
</tr>
<tr>
<td>12</td>
<td>Mahi</td>
<td>34,842</td>
</tr>
<tr>
<td>13</td>
<td>Sabarmati</td>
<td>21,674</td>
</tr>
<tr>
<td>14</td>
<td>West flowing rivers of Kachahh, Saurashtra and Luni</td>
<td>334,390</td>
</tr>
<tr>
<td>15</td>
<td>West flowing rivers south of Tapi</td>
<td>113,057</td>
</tr>
<tr>
<td>16</td>
<td>East flowing rivers between Mahanadi and Godavari</td>
<td>49,570</td>
</tr>
<tr>
<td>17</td>
<td>East flowing rivers between Godavari and Krishna</td>
<td>12,289</td>
</tr>
<tr>
<td>18</td>
<td>East flowing rivers between Krishna and Pennar</td>
<td>24,649</td>
</tr>
<tr>
<td>19</td>
<td>East flowing rivers between Pennar and Cauvery</td>
<td>64,751</td>
</tr>
<tr>
<td>20</td>
<td>East flowing rivers south of Cauvery</td>
<td>35,026</td>
</tr>
<tr>
<td>21</td>
<td>Area of North Ladakh not draining into Indus</td>
<td>28,478</td>
</tr>
<tr>
<td>22</td>
<td>Rivers draining into Bangladesh</td>
<td>10,031</td>
</tr>
<tr>
<td>23</td>
<td>Rivers draining into Myanmar</td>
<td>26,271</td>
</tr>
<tr>
<td>24</td>
<td>Drainage areas of Andaman, Nicobar and Lakshadweep Islands</td>
<td>8,280</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>32,87,260</td>
</tr>
</tbody>
</table>

The National Commission for Integrated Water Resources Development Plan (NCIWRDP), (MOWR, 1999a) made comprehensive assessments on the basis of past studies by government agencies like Central Water Commission (CWC) and Central Ground Water Board (CGWB) and made significant recommendations in its report submitted to the Government of India (GOI) in 1999 towards an integrated and sustainable use of country's water resources. The broad assessments brought out by the NCIWRDP were reflected in the revised National Water Policy (NWP), (MOWR, 2002). Both indicated urgent need for integration of development and management of water resources in all the three sectors for achieving sustainable socio-economic and human development by 2025 by harnessing available water resources. Table 3 summarizes the relevant statistics for India's river basins abstracted from NCIWRDP report. It is seen that out of 4,000 billion cubic meters of water received annually on an average from precipitation of 1,170 mm, the 'natural' renewable water resource is estimated as 1,953 billion cubic meters. This includes the trans-boundary run off received by India, which, although not estimated in the NCIWRDP
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>River Basin</th>
<th>Av. Annual Runoff (MAR)</th>
<th>Live storage</th>
<th>Utilisable Surface Runoff</th>
<th>Percentage of utilisable surface runoff to the average annual runoff (%)</th>
<th>Ratio of total storage to utilisable surface runoff</th>
<th>Ground water</th>
<th>Total utilisable surface runoff and natural recharge</th>
<th>Total utilisable surface water plus ground water including recharge</th>
<th>Percentage of total utilisable water to MAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indus</td>
<td>73.31</td>
<td>13.83</td>
<td>2.45</td>
<td>0.27</td>
<td>17.55</td>
<td>46.00</td>
<td>63.00</td>
<td>0.38</td>
<td>14.29</td>
</tr>
<tr>
<td>2</td>
<td>Ganges-Brahmaputra-Meghna Basin</td>
<td>525.02</td>
<td>36.84</td>
<td>17.12</td>
<td>29.56</td>
<td>83.52</td>
<td>250.00</td>
<td>48.00</td>
<td>0.33</td>
<td>136.47</td>
</tr>
<tr>
<td>3</td>
<td>Subarnarekha</td>
<td>12.37</td>
<td>0.66</td>
<td>1.65</td>
<td>1.59</td>
<td>3.30</td>
<td>6.81</td>
<td>58.00</td>
<td>0.48</td>
<td>1.68</td>
</tr>
<tr>
<td>4</td>
<td>Brahmani-Battarani</td>
<td>28.48</td>
<td>4.76</td>
<td>0.24</td>
<td>8.72</td>
<td>13.72</td>
<td>18.3</td>
<td>64.00</td>
<td>0.75</td>
<td>3.35</td>
</tr>
<tr>
<td>5</td>
<td>Mahanadi</td>
<td>66.88</td>
<td>8.49</td>
<td>5.39</td>
<td>10.96</td>
<td>24.84</td>
<td>49.99</td>
<td>75.00</td>
<td>0.50</td>
<td>13.64</td>
</tr>
<tr>
<td>6</td>
<td>Godavari</td>
<td>110.54</td>
<td>19.51</td>
<td>10.65</td>
<td>8.28</td>
<td>38.44</td>
<td>76.3</td>
<td>69.00</td>
<td>0.50</td>
<td>33.48</td>
</tr>
<tr>
<td>7</td>
<td>Krishna</td>
<td>69.81</td>
<td>34.48</td>
<td>7.78</td>
<td>0.13</td>
<td>42.39</td>
<td>58.02</td>
<td>83.00</td>
<td>0.73</td>
<td>19.88</td>
</tr>
<tr>
<td>8</td>
<td>Pennar</td>
<td>6.32</td>
<td>0.38</td>
<td>2.13</td>
<td>NA</td>
<td>2.51</td>
<td>6.86</td>
<td>110.00</td>
<td>0.37</td>
<td>4.04</td>
</tr>
<tr>
<td>9</td>
<td>Caubry</td>
<td>21.36</td>
<td>7.43</td>
<td>0.39</td>
<td>8.16</td>
<td>19.00</td>
<td>89.00</td>
<td>89.00</td>
<td>0.43</td>
<td>8.79</td>
</tr>
<tr>
<td>10</td>
<td>Tapi</td>
<td>14.88</td>
<td>8.53</td>
<td>1.01</td>
<td>1.99</td>
<td>11.53</td>
<td>14.50</td>
<td>97.00</td>
<td>0.80</td>
<td>6.67</td>
</tr>
<tr>
<td>11</td>
<td>Narmada</td>
<td>45.64</td>
<td>6.6</td>
<td>16.72</td>
<td>0.47</td>
<td>23.79</td>
<td>34.50</td>
<td>76.00</td>
<td>0.69</td>
<td>9.38</td>
</tr>
<tr>
<td>12</td>
<td>Mahi</td>
<td>11.02</td>
<td>4.75</td>
<td>0.36</td>
<td>0.02</td>
<td>5.13</td>
<td>3.10</td>
<td>27.00</td>
<td>1.65</td>
<td>3.50</td>
</tr>
<tr>
<td>13</td>
<td>Sabarmati</td>
<td>3.81</td>
<td>1.35</td>
<td>0.12</td>
<td>0.09</td>
<td>1.56</td>
<td>1.93</td>
<td>50.00</td>
<td>0.81</td>
<td>2.90</td>
</tr>
<tr>
<td>14</td>
<td>West Flowing Rivers of Kachahl and Saurashtra</td>
<td>15.10</td>
<td>4.31</td>
<td>0.58</td>
<td>3.15</td>
<td>8.04</td>
<td>14.98</td>
<td>98.00</td>
<td>0.54</td>
<td>9.10</td>
</tr>
<tr>
<td>15</td>
<td>West Flowing Rivers South of Tapi</td>
<td>200.94</td>
<td>17.34</td>
<td>4.97</td>
<td>2.54</td>
<td>24.85</td>
<td>36.21</td>
<td>18.00</td>
<td>0.69</td>
<td>15.55</td>
</tr>
<tr>
<td>16</td>
<td>East Flowing Rivers Between Mahanadi and Godavari</td>
<td>17.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>East Flowing Rivers Between Godavari and Krishna</td>
<td>1.81</td>
<td>1.63</td>
<td>1.45</td>
<td>0.86</td>
<td>3.94</td>
<td>13.11</td>
<td>56.00</td>
<td>3.33</td>
<td>12.82</td>
</tr>
<tr>
<td>18</td>
<td>East Flowing Rivers Between Krishna and Pennar</td>
<td>3.63</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
Table 3. (Contd...)  
India's Basin-wise Mean Annual Water Resources (MAR) and Utilizable Potential (km$^3$)

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9 = (8/3) x100</th>
<th>10 = 7/8</th>
<th>11</th>
<th>12 = (8+11 +12) x100</th>
<th>15 = (14/3) x100</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>East Flowing Rivers Between Pennar and Cauvery</td>
<td>9.98</td>
<td>1.42</td>
<td>0.02</td>
<td>NA</td>
<td>1.44</td>
<td>16.73</td>
<td>105.00</td>
<td>11.62</td>
<td>12.65</td>
<td>5.55</td>
</tr>
<tr>
<td>20</td>
<td>East Flowing Rivers South of Cauvery</td>
<td>6.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29.38</td>
<td>34.93</td>
</tr>
<tr>
<td>21</td>
<td>Area of North Ladakh not draining into Indus</td>
<td>0.00</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>22</td>
<td>Rivers draining into Bangladesh</td>
<td>8.57</td>
<td>0.31</td>
<td>0.00</td>
<td>NA</td>
<td>0.31</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>23</td>
<td>Rivers draining into Myanmar</td>
<td>22.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>24</td>
<td>Drainage areas of Andaman, Nicobar and Lakshadweep Islands</td>
<td>0.00</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1952.87</td>
<td>173.71</td>
<td>75.43</td>
<td>132.32</td>
<td>381.46</td>
<td>690.32</td>
<td>35.00</td>
<td>0.55</td>
<td>342.43</td>
<td>89.46</td>
</tr>
<tr>
<td></td>
<td>Say</td>
<td>1953</td>
<td>174*</td>
<td>76</td>
<td>132</td>
<td>382</td>
<td>690</td>
<td>35</td>
<td>0.55</td>
<td>342</td>
<td>89</td>
</tr>
</tbody>
</table>

NA – Not assessed  
(1) Denotes potential figures; (2) Without adjustments for imports and exports; 3 Uncorrected for return flows  
* Projects having a live storage capacity of $10^6$ m$^3$ and above are included  
(Source: MOWR, 1999a)
report, can be around 300 billion cubic meters. Thus, the internally generated runoff would be 1,653 billion cubic meters, while 2,347 billion cubic meters would be going back to the atmosphere.

For most parts of India the rainfall takes place under the influence of southwest monsoon between June to September. However, in the southern coastal areas near the east coast (Tamil Nadu and adjoining areas) much of the rain occurs under the influence of the northeast monsoon during October and November. Due to the large spatial and temporal variability in the rainfall, water resources distribution in the country is highly skewed in space, and in time. The Ganga-Brahmaputra-Meghna basin covering 33.5% of the country’s area contributes about 62% of the water resources, and the west flowing rivers with only 3.5% of area contribute as much as 10% of the water resources.

The replenishable natural ground water resources part of the total natural renewable water resources of India have been estimated as about 342 billion cubic meters by CGWB. The current level of recharge to groundwater from irrigation has been estimated at about 89 billion cubic meters. Thus, the current estimate of the renewable groundwater resource as made by CGWB is about 431 billion cubic meters. The basin-wise natural recharge to groundwater and recharge from surface water utilization worked out by the NCIWRDP on the basis of district-wise estimates of CGWB, are also given in Table 3. In all, potentially utilisable surface water and ground water are considered at 690 billion cubic meters and 342 billion cubic meters respectively. The total utilisable water resources of 1,032 billion cubic meters, is about 55% of the renewable water resources and only 27% of precipitation.

Reservoirs and Barrages

Storage projects providing live storage capacity of 177 billion cubic meters have been constructed. Projects under construction are likely to add another 75 billion cubic meters. Contribution expected from the projects under planning is 130 billion cubic meters. Thus, on completing all on going and contemplated new projects, total storage is likely to reach 382 billion cubic meters (Table 3). These projects do not include minor storages. The number of dams so far constructed in India for various purposes such as irrigation, hydel-power, flood control etc. is around 4000. Considering the large quantum of water still to be harnessed to meet the future requirements, apart from completing the on-going projects, approximately another 2500 large dams would still be required to be constructed in India. About 250 barrages/anicuts have been constructed in the country so far and 45 barrages/anicuts are under construction.

2.2 Population and Food Security

The population of India in 2001 was 1,027 million. After examining the latest trends and views expressed by different demographers, NCIWRDP considered both the higher and lower limits of population projection as 1,333 million and 1,286 million in the year 2025, of which upper and lower limits of urban population were estimated to be 603 million and 476 million, respectively.

The per capita availability of natural water in the country was 1,901 m³/year in 2001 and it is estimated to decrease to 1,518 m³/year in 2025. However, in several river basins, sub-basins the per capita availability of water is likely to be less than 1000 m³/year in 2025.

2.3 Water for Food

The annual production of food grains in India has increased from around 50 million tones in the 1950s to about 208 million tones in the year 1999-2000. Using the population projections in 2025, the total annual food grain requirement of the country has been estimated by NCIWRDP to be between 320 and 308 million tonnes. The National Water Policy (MOWR, 2002) envisages that the annual food grain production will have to be raised to around 350 million tonnes by the year 2025.

The National Agriculture Policy (NAP, 2000) envisages a growth rate exceeding 4% per annum in the agriculture sector. The food grain requirement by the end of the Tenth Five Year Plan (2006-07) is 240 million tonnes as per the Working Group constituted by the Planning Commission. This calls for integrated management of irrigated and rain-fed agriculture.

Ultimate Irrigation Potential

In India, the “irrigation potential”, or the capacity of a project/area/state to irrigate, with the infrastructure as it exists, is counted in terms of the gross irrigated cropped area, based on designed cropping pattern and irrigation intensity. This gross irrigated cropped area is larger than the net irrigated area, by the irrigated area cropped more than once, annually. The “ultimate” irrigation potential represents the upper bound of the potential, with all the envisaged water storage, diversion and distribution infrastructure, in place.
In India, the irrigation projects are classified into three categories namely major, medium and minor projects. Projects which have a cultivable command area (CCA) of more than 10,000 ha are termed as major projects those which have a CCA between 2000 ha–10,000 ha are termed as medium projects and those which have a CCA of less than 2,000 ha are classified as minor projects.

Currently, the economically and environmentally sustainable ultimate irrigation potential of the country is assessed at 140 Mha of which, 58.46 Mha is from major and medium irrigation projects, 17.38 Mha from minor surface water schemes and 64.05 Mha from minor ground water schemes including the privately owned shallow wells, tube wells and bore wells. This assessment of ultimate irrigation potential could undergo a revision with the improvement in technology and economic developments.

Against an ultimate irrigation potential of 58.46 Mha from major and medium projects, 35 Mha (60%) has been developed so far. This gigantic task has been accomplished by undertaking 375 major projects, 1,118 medium projects and extension, renovation and modernization (ERM) of 177 of old projects. Till the end of Ninth Five Year Plan (1997-2002), a potential of 56.90 Mha was created through minor irrigation schemes. It is anticipated that 8 Mha potential will be created by the end of the Tenth Five Year Plan (2002-2007), bringing the total irrigation potential to about 100 Mha. The net area of 57 Mha has so far been brought under irrigation, which is about 40% of the net sown area. India has the largest irrigated area amongst all the countries.

**Water Requirement**

The NCIWRDP has estimated the requirement for irrigation to meet food grain demand in the country to remain self-sufficient in food grains. The water withdrawal requirement in 2025 for irrigation from both surface and groundwater is estimated at about 611 billion cubic meters and 560 billion cubic meters, respectively assuming overall irrigation efficiencies of 50% for surface water systems and 72% for groundwater systems. The national average food grain production yields are expected to increase to a level of about 3.5 t/ha for irrigated areas and 1.25 t/ha for rain-fed areas.

**Rain-fed Areas and Rain-fed Agriculture**

Rain-fed area accounts for two-thirds of the total cultivated land of 142 Mha and irrigated area accounts for the remaining one-third. However, food grain production in rain-fed areas is only 45% of total food grains produced against 55% produced in irrigated areas. In future, the contribution of rain-fed area is likely to decrease, but will still remain very significant.

Rain-fed agriculture is characterized by low levels of productivity. Being dependent on rainfall, crop production is subject to considerable instability from year to year. More than 200 million of the rural poor live in the rain-fed regions. These risk prone areas exhibit a wide variation and instability in yields. The gap between yield potential and actual yields is very high compared to the irrigated areas.

All areas where rain-fed farming is dominant whether in the central plains, hills, semi-arid or coastal lands, will need to contribute more to poverty alleviation, and augment food security by producing marketable surpluses more reliably. If the targeted food grain production is to be achieved, productivity enhancement of rain fed areas becomes a critical factor in the production process (MOA, 1998).

The watershed approach to rain fed farming is a major strategy of the Government of India for enhancing agricultural growth in the rain fed regions. The key attributes of watershed management technology are conservation of rainwater and optimisation of soil and water resources in a sustainable and cost effective manner.

The Committee on “25 Years Planning Commission Perspective Plan of the Development of Rain fed Areas”, constituted by the Planning Commission, Govt. of India in 1997, recommended treating/development of 75 million ha of arable and non-arable lands by the end of the 13th Five Year Plan (2017-2022) with a total cost of Rs. 209 billion.

The Ministry of Agriculture has been entrusted with the task of conservation of land and water resources, optimising production in rain-fed areas and reclamation of degraded lands. The following schemes are being implemented for this purpose – (i) National Watershed Development Project for Rain-fed Areas; (ii) Soil and Water Conservation in the Catchment of River Valley Projects and Flood Prone Rivers (iii) Reclamation of Alkali Soils; (iv) Watershed Development Projects in Shifting Cultivation Area.

ICID had entrusted to an NGO, namely, Society for Promoting Participative Eco-System Management (SOPPECOM, 2003), a study of two micro-watersheds, each
of about 500 ha to apply and demonstrate the concept of building knowledge base for rain-fed areas for assessment of possible options through a combination of scientific and participative approaches. Watershed of Mehru village in Sabarmati River Basin and Manmodi village of Jalgaon district in Tapi River Basin were selected. The following key issues were highlighted in the study.

- Need to provide water for basic domestic / cattle / food security requirements on priority,
- Consensus on policies regarding water rights and biomass entitlements,
- Produce sharing and price fixation' agreements,
- Creation of enduring institutions for enforcement of policy,
- Adoption of alternative approaches to optimise water and input use for entire area of watershed to minimize dependence on external inputs of chemicals and energy and investments on equipment and facilities provided from outside,
- Enhancement of water availability and improvement of productivity,
- Innovations adopted by farmers related to advances in crop production technologies with limited water and irrigation, soil improvement and organic inputs should be fully utilized,
- Evaluation and monitoring of experiences related to yield response and influence of soil moisture deficit on consumptive use for at least one hydrological year and extend the efforts to 3 years for identification of policy interventions,
- Integrated approach for development and management of local resources combined with optimum and regenerative use of exogenous water for wastelands, forests and irrigated watersheds,
- Reorientation of financing system of irrigation/rural development through interest subsidy for water-saving equipment, use of biomass / solar energy for saving fossil fuels, revision of pricing to promote water-efficient cereals and biomass,
- Integration of total public assistance for rural development, irrigation and concessional credit, and phased withdrawal of subsidies including employment assistance and interest subsidy, and
- Documentation of successful scientific analysis for skill-intensive, low cost, low water and chemical input.

2.4 Water for People

Water Requirement for Domestic Sector

Future domestic water demands depend on projections of rural and urban population and on the per capita norms for supply. The norms of supply can change with time, as the income and standards of living rise. NCIWRDP has made estimates of the requirements of domestic water based on projections of population for the year 2025. It is estimated that urban population would be about 45% of the total population by 2025.

The per capita norms for domestic supply adopted for the year 2025 for the urban areas as used by the NCIWRDP (1999), are: Class 1 cities (having population more than 1 million) @ 220 litre per capita per day (lpcd) and for cities other than Class 1 @ 165 lpcd; and for rural areas @ 70 lpcd.

The total water requirement for domestic use for rural and urban areas for human population and livestock as estimated by NCIWRDP for the year 2025 varies between 62 billion cubic meters and 55 billion cubic meters. The Commission considered that 70% of urban and 30% of rural water supply requirements would be met from surface water resources and the balance from ground water resources.

Currently, the Ministry of Urban Development specifies the following norms for urban domestic water supply:

- Towns with piped water supply but without sewerage system @ 70 lpcd.
- Cities with piped water supply and existing or planned sewerage system @ 135 lpcd
- Metropolitan and mega cities with piped water supply and sewerage at 150 lpcd.
- Public stand posts @ 40 lpcd.

For piped water supply, 15% distribution losses are also considered while working out the requirement.

The norms for water supply followed in the rural areas are as follows:

- For people, 40 lpcd and one safe source for 250 persons, within a distance of 1.6 km in the plains and 100 m vertical distance in the hills.
For livestock, 30 lpcd.

The urban and rural water supply schemes at present are following the norms prescribed by the Ministry of Urban Development and the fund allocations are made to the various States accordingly, by the Government of India.

Present Coverage of Water Supply

Urban water supply

As per Census 2001, there are 53.69 million urban households. Out of these, 36.86 million households have tap water supply and remaining have hand pumps. Out of 36.86 million urban households 26.67 million households have tap in the premises, and 8.08 million households have tap just outside the premises and the rest 2.09 million households have tap within 100 meters. Drinking water requirement of most of the mega cities are met from reservoirs of irrigation or multi-purpose schemes existing nearby and even by long distance transfer. Only 77 of the 299 class-I cities have 100% water supply coverage. 203 of the 345 class-II cities have supply of less than 100 litres per capita per day. More than 50 percent of water for urban domestic and industrial use is drawn from groundwater.

Rural water supply

As per the current practice, a rural habitat is considered to have a safe source of water, if the source, adequate in quantity and quality terms, is available within a specified distance and a specified elevation difference.

There are 1.422 million habitations in India. Safe source of water supply is available to 1.356 million habitations (95%), while 0.061 million habitations are partially covered and 0.005 million habitations do not have a safe source of water supply. About 98% of the rural population have access to safe drinking water through 3 million hand pumps and stand posts and about 1,16,300 mini and regional piped water supply schemes. More than 85 percent of rural water supply is groundwater based and consumes about 5 percent of the total annual replenishable groundwater. Sustainability of the rural water supply is a matter of concern and is adversely affected due to the decline in ground water levels and the deterioration of ground water quality. A total of 0.217 million habitations in the country have water quality problems like excess fluoride, excess salinity or/and excess iron. Excess of arsenic is also found in parts of West Bengal posing a health hazard to 6 million people. Safe drinking water to all habitations is planned to be provided by March 2007.

Present coverage of sewerage

By the year 2000, about 75-81% of all urban households had toilets. Whereas, in the rural area, only 28% of rural households had toilets. Full sanitation will be covered in all the 451 districts by the end of 11th Five Year Plan (2007-12). The coverage in respect of organised sewerage ranges from about 35% in Class IV cities to 75% in Class I cities. Out of 300 Class I cities 70% have partial sewerage and sewage treatment facilities. A Central Pollution Control Board (CPCB) study in 1994-95 indicates that 300 Class I cities produce 15,800 mld of sewage, while the treatment capacity was hardly 3,750 mld. In 23 metro cities, 9,000 mld of sewage was generated, of which 60% is from the 4 mega cities of Mumbai, Delhi, Calcutta, and Chennai. Hardly 30% of sewage generated in the metro cities is treated before disposal. Most of the cities have only primary treatment plants and as such partially treated and untreated sewage finds its way into the water bodies causing water pollution.

A survey of 345 towns with population between 50,000 and 60,000 has indicated that over 95% do not have any wastewater treatment facilities. The mode of sewage disposal is on land for direct or indirect use for irrigation. The problem of pollution of river is particularly acute in the case of densely populated cities located on riverbanks, which do not have adequate facilities for sewage treatment. Currently the Ministry of Environment and Forests (MOEF) is implementing a massive programme of cleaning rivers and lakes in the country. The programme extends to polluted stretches of 27 major rivers with works spread over 149 towns in different states.

Some common issues related to water supply and sanitation faced in urban and rural areas in India is given in Annexure 1.

Water Supply Status in Selected Locations

The status and issues related to water supply status in domestic and industrial sectors were studied through a study of ten cities/urban conglomerates and in one industrial conglomerate viz. Angul-Talcher. (in Brahmani basins of Orissa state). Data on urban water supply and sanitation was collected from local bodies through a questionnaire with the help of interviews with concerned officials, routine reports of the municipal water and sanitation agency, relevant newspaper stories and other publications. Annexure 2 gives details of the study.
Water Policy Issues of India

Water Requirements of Industrial Sector

Regional/national industrial water demands are driven by growth of the industry, which in turn is linked with growth of per capita Gross Domestic Product. Requirement of water for industries varies from industry to industry and on production and water use technology. On account of these complexities and lack of data, it is a challenging task to make accurate assessments of future industrial water demand. Technological changes in industrial production may have significant bearing on the future industrial water requirement.

A sub-group set up by the Department of Industrial Development in 1997 have worked out the requirement of water for industrial purposes and projections for the year 2025 and 2050, based on the available data on production and technological trends in respect of 13 major industries in the country. Annual requirement of water in 2025 as assessed by the sub group is 22.93 billion cubic meters.

The NCIWRDP also worked out the requirement of water for various industrial uses based on water requirement per unit of production and production figures of 17 categories of industry and projected the requirement for the country up to 2050. The NCIWRDP assessed total annual water requirements of the industrial sector by 2025 as 67 billion cubic meters per year. The corresponding industrial wastewater generation was assessed as 44 billion cubic meters per year.

As per the CPCB Act, every industry should have its own treatment plant for treating wastewater from the industry, to the prescribed standards. In practice this is not strictly followed and there is a need for strict monitoring and control. There are a number of unorganised small-scale industrial units, which discharge industrial wastewater without any treatment, causing pollution of the water bodies. Common effluent treatment plants should be set up by the department of industry, and the industry should share proportionate capital, operating and maintenance costs. Industries must be compelled to treat the hazardous waste and dispose it off safely, to protect the environment from adverse impacts. Several stretches of many of the rivers are badly polluted by discharge of industrial wastewater and domestic sewage. CPCB identified several river reaches and remedial measures have been initiated by some of the industries and municipal bodies, to reduce the pollution load in the water bodies.

2.5 Water for Nature

NCIWRDP considered two types of water requirements for nature under environment and ecology while assessing total water demands – (a) for afforestation and tree planting and (b) for abatement of water pollution and water quality management in rivers. No provision has been made for type (a) requirement, as they did not envisage the use of irrigation for these purposes, including for growing nurseries these are expected to be met from the rain and moisture. Some ad hoc provision for type (b) In regard to an ad hoc provision of 10 billion cubic meters (2025) was made for maintenance of water quality to keep the Bio-chemical Oxygen Demand (BOD) level of treated effluents to safe limits through dilution.

In the approach of NCIWRDP, as also in the approach, which is currently being followed, ‘water resource’ was the renewable resource available in the rivers and in the aquifers. Thus, any use of the precipitation was not considered as the use of the ‘water resource’. This explains how the large natural uses of precipitation, by the natural ecosystem like forests; grasslands etc. were not reflected in their water requirements. (The CPSP approach considers the precipitation as the primary water resource, and this overcomes such anomalous situation).

In regard to the reservation of water for the sustenance of natural ecosystem, the provision of 10 billion cubic meters as made would be supplemented by separate but complementary reservations for navigation and hydropower.

2.6 Total Water Requirement

The NCIWRDP assessed that all the utilisable waters will have to be harnessed before 2025, to meet the integrated water needs for food, people and nature. The NCIWRDP estimates that by the year 2025, on the basis of high population growth, total demand could be 843 billion cubic meters. The present demand of 629 billion cubic meters is 64% of the utilisable water resources. The remaining water resource development calls for massive investment, inclusion in five-year-plans, and concerted efforts. It involves several issues related to complex technical, environmental, and socio-economic aspects. Water Demands for various sectors for 1998 and 2025 are given in the Table 4.

By 2050, the total demand for water would be 1,180
billion cubic meters of which irrigation demand would be 807 billion cubic meters. Thus, the total demand would go beyond the currently estimated potential utilisable resources.

Expansion of availability of utilisable waters

There is an urgent need for expanding the water availability through non-conventional means even after adding a substantial new storage capacity (to a total of 450 billion cubic meters by 2050) and better utilization of replenishable groundwater. Following are the options arranged in the order of likely availability.

- Inter-basin transfers
- Recycling and reuse of waste waters
- Watershed development and rain water harvesting
- Artificial recharge
- Desalination (though unlimited, it is expensive under present conditions).
- Adoption of scientific water management technologies in agriculture.

Some of these approaches are already been adopted.

2.7 Water Quality

In recent times, quality of both surface water and groundwater sources are deteriorating due to increasing quantities of disposal of untreated of industrial and domestic waste water in to fresh water bodies; besides non-point source pollution due to return flows from agricultural lands also cause deterioration.

Water quality and health are closely interlinked. Improving the quality of drinking water, and providing sufficient water, for both personal and domestic hygiene are keys to prevention or control of major water borne diseases such as diarrhoea, cholera, typhoid, guinea-worm diseases, hepatitis, polio, filariasis, dengue and malaria.

Water quality issues are becoming critical as groundwater depletion increases. Widely prevalent problems in sustainable supply of drinking water are brackishness and excess fluoride content. These are mainly in low rainfall and high potential evaporation areas. An integrated water management approach is necessary to solve these problems. Water harvesting and conservation measures in a watershed, with artificial recharge of aquifers whenever feasible may lead to mitigation of the above problems.

In large tracts of rural area, where water quality problems exist in spot sources, it may be necessary to go in for a piped water supply from a distant and safe source involving storage, transportation and laying of distribution system.

The Rajiv Gandhi National Drinking Water Mission has constituted sub-missions for initiating preventative and remedial measures. Programmes include those on Arsenic, brackishness, Iron, and sustainability.

2.8 Institutional Framework for Water Resources Development

The constitution of India lays down the legislative and functional jurisdiction of the union, state and local governments regarding ‘Water’. Of the total geographical area of India, some 92 percent is covered by interstate river basin. The constitution provides for the regulation of the inter-state river waters, by the Union, in national interest, if the Union Legislature provides for and prescribes the extent of such regulation, through an enabling act. At present, except for the River Board Act (1956), (which is dormant), the Brahmaputra Board Act and the Betwa River Board Act, no such enabling enactments are available. In the absence of these, the states can deal with the waters of the inter-state rivers also, by themselves. However, if inter-state river water disputes arise, the union is empowered to get these resolved through the Inter-State Water Dispute Tribunals. There is a need for holistic and integrated water resources development and management to augment the net water availability, harnessing the water available in various phases of the hydrological cycle. The Central Government is responsible for planning the development of water resources in a coordinated manner. Ministry of Water Resources was formed to assume a nodal role in

### Table 4. Water Demands for Various sectors in 1998 and 2025 in India

<table>
<thead>
<tr>
<th>Sector</th>
<th>1998</th>
<th>2025</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>524</td>
<td>618</td>
<td>807</td>
</tr>
<tr>
<td>Domestic use</td>
<td>30</td>
<td>62</td>
<td>111</td>
</tr>
<tr>
<td>Industrial use</td>
<td>30</td>
<td>67</td>
<td>81</td>
</tr>
<tr>
<td>Inland Navigation</td>
<td>0</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Power</td>
<td>9</td>
<td>33</td>
<td>70</td>
</tr>
<tr>
<td>Environment</td>
<td>0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Evaporation losses</td>
<td>36</td>
<td>50</td>
<td>76</td>
</tr>
<tr>
<td>Total</td>
<td>629</td>
<td>850</td>
<td>1180</td>
</tr>
</tbody>
</table>

regard to all matters concerning the country’s water resources and to underscore the multifarious uses of water and need for integrated development.

The Ministry of Water Resources is responsible to lay down the policies for development, conservation, augmentation, productivity and protection of water resources. The Ministries of Water Resources of State Governments are responsible for the execution and maintenance of water resources projects. Although the Ministry of Water Resources (GOI) is the nodal ministry of the Centre, presently water as a subject is being dealt within the Central Government by different ministries as shown in Table 5.

The National Water Resources Council (NWRC) representing all the States and the concerned Ministries of the Union was set up in 1983 under the Chairmanship of the Prime Minister. The important functions of the Council are to lay down the National Water Policy and to review it from time to time, to advise on the modalities of resolving inter-state differences, to advise practices and procedures, administrative arrangements and regulations for the fair distribution and utilization of water resources by different beneficiaries and to make such other recommendations as would foster expeditious, environmentally sound and economical development of water resources in various regions.

The National Water Board constituted by the Government of India, with the Secretary, Ministry of Water Resources as the Chairman and Secretaries of the concerned Union Ministries and Chief Secretaries of States as its members, is responsible to review the progress of implementation of National Water Policy, to recommend pattern of financing of water development projects, to suggest investment priorities for achieving the objectives of the National Water Policy.

The NWRC, although has the highest level of representation, is an advisory body and is also without any legal backing. The decisions of the NWRC are to be taken by consensus, but this process is undefined. The main outcome of NWRC, so far, is in terms of evolving and adopting the National Water Policy as also other subsidiary water related policy documents. However, such an adoption does not seem to bind the States in implementing the relevant principles within their jurisdiction.

The multiplicity of institutions dealing with water, with only a loose co-ordination, continues at the level of the State Government also. Many states have, by now, finalised the State Water Policies.

Both the National and State Water policies appear to be more in the form of statements of intentions. The follow up actions, in deciding relevant strategies, in preparing time bound action plans, in revising legislations to meet the policy objectives, and in changing rules and procedures to implement the policies at the cutting edge, are generally missing.

Table 5.
Ministries/Department of GOI Dealing With the Subject of Water and Related Issues

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Ministry/Department</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Water Resources</td>
<td>Irrigation, command area development, flood control, groundwater</td>
</tr>
<tr>
<td>2.</td>
<td>Agriculture</td>
<td>Micro irrigation, soil conservation, drought management and watershed programmes.</td>
</tr>
<tr>
<td>3.</td>
<td>Rural Development</td>
<td>Rural drinking water supply and rural sanitation, watershed programmes</td>
</tr>
<tr>
<td>4.</td>
<td>Urban Development</td>
<td>Urban drinking water and urban sanitation</td>
</tr>
<tr>
<td>5.</td>
<td>Environment &amp; Forest</td>
<td>Pollution control, environment and forest clearance</td>
</tr>
<tr>
<td>6.</td>
<td>Power</td>
<td>Hydro power</td>
</tr>
<tr>
<td>7.</td>
<td>Shipping</td>
<td>Inland navigation</td>
</tr>
<tr>
<td>8.</td>
<td>Planning Commission</td>
<td>Allocation of Five Year Plan funds for various sectors and investment clearance.</td>
</tr>
<tr>
<td>9.</td>
<td>Dept. of Science and Technology (DST)</td>
<td>Research &amp; Development, science &amp; technology policies, desalination techniques</td>
</tr>
<tr>
<td>10.</td>
<td>Dept. of Atomic Energy</td>
<td>Water related concerns of Nuclear Plants, isotope hydrology</td>
</tr>
</tbody>
</table>
CHAPTER 3
PREVAILING POLICIES AND VISION FOR INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT

3.0 Introduction

A National Water Policy (NWP) was, in the first instance, adopted in 1987 by Government of India. Subsequently, a number of issues and challenges emerged in the development and management of water resources. Therefore the National Water Policy was reviewed, updated and a revised water policy was adopted by the National Water Resources Council in 2002 (MOWR, 2002). The policy touches upon the availability of surface and ground water and utilizable water resources as per the latest assessment, estimated requirement of food grain production by the year 2025, water resources planning by conventional and non-conventional means, institutional mechanism, water quality, water allocation priorities, resettlement and rehabilitation, participatory approach to water resources management, water sharing and distribution amongst the states, and maintenance of minimum flow requirement in the streams for maintaining ecology and social considerations. The National Water Policy is presented in Annexure 3 and the clauses related with the CPSP activities are highlighted.

At present the Ministries of Agriculture, Rural Development, Urban Development, Environment and Forests, shipping, Power, and Atomic Energy, are also involved in the management of water resources in addition to the Ministry of Water Resources. The extracts related to water covered in the National Policy of Agriculture (2000) formulated by the Ministry of Agriculture, and the draft National Environment Policy formulated by the Ministry of Environment are given in Annexure 3a, and 3b, respectively.

Ministry of Water Resources formulated the Vision for Integrated Water Resources Development and Management in 2003. The India Water Partnership (IWP) prepared an India Water Vision 2025 based on a number of national and zonal level discussions and meetings in 2000. The extracts of these vision documents are given in Annexure 4. The highlights of policies reflected in the documents of different Ministries in so far as they relate to the present studies are detailed below:


Water is part of a larger ecological system. Realising the importance and scarcity attached to the fresh water, it has to be treated as an essential environment for sustaining all life forms. In view of increasing scarcity and the vital importance of water for human and animal life for maintaining ecological balance and for economic and developmental activities of all kinds, the planning and management of water resource in an optimal, economical and equitable basis is a matter of the utmost urgency. Concerns of the community needs should be taken into account for water resources development and management.

The success of the National Water Policy will depend entirely on evolving and maintaining a national consensus and commitment to its underlying principles and objectives. To achieve the desired objectives, State Water Policies backed with an operational action plan need to be formulated in a time bound manner. National Water Policy need to be revised periodically as and when need arises.

3.2 National Agriculture Policy (2000)

Agriculture is a way of life, a tradition, which, for centuries, has shaped the thought, the outlook, and the economic life of the people of India. Agriculture, therefore, is (and will continue to be) central to all strategies for planned socio-economic development of the country. Rapid growth of agriculture is essential not only to achieve
self-reliance at national level but also for household food
security and to bring about equity in distribution of income
and wealth resulting in rapid reduction in poverty levels.
The National Policy on Agriculture aims to attain:

- A growth rate in excess of 4 per cent per annum in
  the agriculture sector
- Growth that is based on efficient use of resources
  and conservation of soil, water and bio-diversity
  resources;
- Growth with equity, i.e., growth which is widespread
  across regions and farmers;
- Growth that is demand driven and caters to domestic
  markets and maximizes benefits from exports of
  agricultural products in the face of the challenges
  arising from economic liberalization and
  globalization.
- Growth that is sustainable technologically,
  environmentally and economically.

A major thrust will be given to development of rain-fed
and irrigated horticulture, floriculture, roots and tubers,
plantation crops, aromatic and medicinal plants, bee-
keeping pisciculture and sericulture, for augmenting food
supply, exports and generating employment in the rural
areas.


The policy recommends an increase of forest and tree
cover from the present level of 23 percent of the country's
land area to 33 percent by 2012, through afforestation of
degraded forest lands, wastelands, and tree cover on private
or revenue lands.

The action plan for management of river systems
includes the following:

- Promote integrated approaches to management of
  river basins by the concerned river authorities,
  considering upstream and downstream inflows and
  withdrawals by season, pollution loads and natural
  regeneration capacities, to ensure maintenance of
  adequate flows and adherence to water quality
  standards throughout their course in all seasons.
- Consider and mitigate the adverse impacts on river
  flora and fauna, and the resulting changes in the
  resource base for livelihoods, of multipurpose river
  valley projects, power plants, and industries.

- Consider mandating the installation of water saving
  closets and taps in the building byelaws of urban
  centres.

The action plan for management of groundwater
includes the following:

- Take explicit account of impacts on groundwater
  tables on electricity tariffs and pricing of diesel.
- Promote efficient water use techniques, such as
  sprinkler and drip irrigation, among farmers.
- Provide necessary pricing, inputs, and extension
  support to feasible and remunerative alternative
crops from efficient water use.
- Support practices of contour bunding and revival
  of traditional methods for enhancing groundwater
  recharge.
- Mandate water harvesting in all new constructions
  in relevant urban areas, as well as design techniques
  for road surfaces and infrastructure to enhance
groundwater recharge.
- Support R and D in cost effective techniques suitable
  for rural drinking water projects for removal of
  arsenic (fluoride and heavy meal contamination)
  and mainstream their adoption in rural drinking
  water schemes in relevant areas.

For the development of wetlands, the following
suggestions have been made in the policy:

- Set up a legally enforceable regulatory mechanism
  for identified valuable wetlands to prevent their
degradation and enhance their conservation.
  Develop a national inventory of such wetlands.
- Formulate conservation and prudent use strategies
  for each significant catalogued wetland, with
  participation of local communities, and other
  relevant stakeholders.
- Formulate and implement eco-tourism strategies for
  identified wetlands through multi stakeholder
  partnerships involving public agencies, local
  communities, and investors.
- Take explicit account of impacts on wetlands of
  significant development projects during the
  environmental appraisal of such projects; in
  particular, the reduction in economic value of
  wetland environmental services should be explicitly
  factored into cost-benefit analyses.
• Consider particular unique wetlands as entities with “Incomparable Values”, in developing strategies for their protection.

In order to tackle the direct and indirect causes of pollution of surface water sources (river, lakes and wetlands), groundwater, and coastal areas, the following action plan as recommended are of relevance:

• Develop and implement, initially on a pilot scale, public-private partnership models for setting up and operating effluent and sewage treatment plants. Once the models are validated, progressively use public resources, including external assistance, to catalyse such partnerships. Enhance the capacities of municipalities for recovery of user charges for water and sewage systems.

• Enhance reuse of treated sewage and industrial wastewater before final discharge to water bodies.

• Enhance capacities for spatial planning among the State and Local Governments, with adequate participation by local communities, to ensure clustering of polluting industries to facilitate setting up of common effluent treatment plants to be operated on cost recovery basis.

• Promote R and D in development of low cost technologies for sewage treatment at different scales.

• Take explicit account of groundwater pollution in pricing policies of agricultural inputs, especially pesticides, and dissemination of agronomy practices involving their use.

3.4 National Policy on Tribals

The Government of India is now proposing, for the first time, a National Policy on scheduled tribes. Earlier, there was no documented policy, but the five principles of Nehruvian Panchsheel were guiding the tribal affairs.

The Press Release of the Ministry of Tribal Affairs (MoTA) dated May 19, 2005 is enclosed as Annexure 5. The main provisions in the proposed set up are:

i) More funds would be made available for the project for irrigating tribal lands.

ii) Tribal communities would be given settling land rights in the forest area. For this purpose, the Ministry of Tribal Affairs is formulating a “Scheduled Tribe (Recognition of Forest Rights) Bill”. This will give the tribals the responsibility and authority for sustainable use of forestland. Perhaps, each tribal family may be given a right to sustainably cultivate upto 2 ha of forestland, for their livelihood. Irrigating such lands may also become possible.

iii) The tribals would be given ownership right on minor forest produce. For this purpose, the Ministry of Environmental and Forests (MoEF) is likely to draft a “Model State Minor Forest Produce (Ownership of Forest Dependent Community) Bill”. These measures, along with the authority to cultivate forest areas, may improve the livelihood of the tribals, and the economic carrying capacity of the forest areas, to sustain the population.


The vision is optimal sustainable development, maintenance of quality and efficient use of country’s water resources to match the growing demands on this precious natural resource with active involvement of all stakeholders in order to achieve accelerated, equitable economic development of the country. Extracts of the Vision for Integrated Water Resources Development and Management framed by Ministry of Water Resources, Government of India (2003) are given in Annexure 4.

The objectives enshrined in this vision are designed to be achieved by adopting a systematic policy focus, administrative initiatives, and enacting suitable legal instruments for:

• Ensuring participation and cooperation of various sections of the society, stakeholders

• Devising appropriate economic and financial instruments to facilitate proper and sufficient flow of funds for water resources development,

• Bridging the knowledge gap through research, training and documentation to enable educated decision making, and

• Facilitating appropriate social changes for educated involvement of all stakeholders in water resources, planning, development and its management.
3.6 India Water Vision 2025 framed by India Water Partnership (2000)

The Global Water Partnership (GWP) is a working partnership among all those involved in water management: government agencies, public institutions, private companies, professional organisations, multilateral development agencies and others committed to the Dublin-Rio principles. South Asia is one of the 12 regional water partnerships. Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka are partner countries in GWP South Asia. The India Water Vision 2025 was initiated by Global Water Partnership and by the South Asia Technical Advisory Committee of the GWP. The report is based on consultations and meeting 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.

Various vision elements and key drivers identified by the India Water Partnership (IWP) during 2000 through many consultations are given in Annexure 6. Using the vision elements and key drivers, two scenarios have been developed for 2025 for ensuring food security, livelihood security, health security and ecological security. A total water demand of 1027 billion cubic meters and an investment of Rs. 5,000 billion have been estimated to meet the water demand in 2025. Such massive investments in new projects should be planned within the framework of integrated scheme for river basin development plan. Further, development of water resource projects would require explicit assessment of environment and social impacts.

3.7 Notes on New Policy Initiatives on Environments and Tribal Affairs

The new developments due to the evolving policy initiatives of MoEF and MoTA would have some water related implications, which have not been quantified. There is a need to do this, and BHIWA or similar models can be effectively used for this purpose.

1. The MoEF draft Policy envisages increase in forest cover, both by improvement of degraded forests, as also by conversion of wastelands. The consequent increase in evapo-transpiration will reduce the river flows; overall, although the inter-annual variation may sometime improve. The reduction of flows may stress or limit other uses as follows:

a) Water use may have to be reduced. If D&I use cannot be reduced, the reduction would have to be mainly in irrigation.

b) The flows available in the river, after extractions, would reduce. This may affect the aquatic ecology. However, if the environmental flow requirements have also been specified to meet these requirements in the face of reducing flows, the water use for irrigation, D&I etc. would have to be reduced further.

2. The policy changes being brought in by the Ministry of Tribal Affairs would, as discussed, improve the tribal incomes etc. The evapo-transpiration needs of forests may be reduced marginally, but if the forest plots allocated to the tribals are irrigated, ET may not reduce much. The agricultural and irrigation water use would increase, and so would the food grain production.
4.0 Introduction

The water related policies as discussed in Chapter 3, have been evolved, by each group of decision makers, independently, on the basis of considerable information. However, the implications of these policies were not tested on any sample basins in an integrated and holistic way.

The CPSP aims at filling the gap, and in producing both a tool for such testing (the BHIWA model) and an array of results, for different scenarios, which could be analysed by the stakeholders. This process was followed. The stakeholder consultations were held, after informing them about the model and its results, so that informed discussions on the policy related issues are facilitated.

The preparatory workshop and basin level consultations held in October 2002 helped to enhance the knowledge base and select the basins, define additional studies for improving the preliminary estimates of water availability and water use. Subsequently a preparatory workshop on the Hydrologic Modelling for meeting CPSP goals was held in August 2003 to identify further work regarding development of model for detailed basin level water assessment. A National Level Consultation was organized in November 2003 in which the modelling of two Indian river basins and key findings based on comprehensive assessments for past, present and alternative future scenarios, extrapolation of assessment of these basins to other basins, environmental and policy related issues emerging from these assessments were presented and discussed. The previous studies as well as other findings were revisited considering the various suggestions and comments received from the participants at the consultation and a new module for projection of D&I requirements was added to the model. A report on “Policy Issues: India Country Study” was also presented at the ICID special session held on the side lines of 55th meeting of IEC of the ICID held at Moscow. Details of Workshops and consultations for CPSP studies held in India are given in Annexure 7. The agencies and experts, who joined the consultative process and suggestions and comments received during Indian National Consultation held on 21-22 November, 2003 are given in Annexures 8, and 8a respectively.

4.1 Modelling Framework

A holistic model viz. Basin-wide Holistic Integrated Water Assessment (BHIWA) Model was especially developed to provide an integrated computational framework for a basin/sub-basin level assessment of water resources with a view to evaluate water sector policies, keeping CPSP goals in mind. The model considers the entire land phase of the hydrologic cycles and is capable of depicting human impacts such as changes in land and water use, as also impacts of water storage and depletion through withdrawals for various water uses and addition through returns/ inter-basin water transfers. The basic objectives of the model are:

- To consider the impact of changing land and water use on the resources, taking into account inter-dependencies between different elements of the land phase of the hydrological cycle
- To quantify and integrate sectoral water uses, and
- To formulate and analyse scenarios to evaluate various policy options for development and management of water and related land resources.

The model can be used effectively for the following purposes:
a) Understanding resources and sectoral needs in an integrated manner considering sustainability of water for human use as well as environment, and

b) Creating and improving knowledge base for meaningful and transparent dialogue.

The model was calibrated based on data for present conditions and applied to identify main issues and challenges in basin water management and explore policy options through the analysis of alternate scenarios of the future (year 2025). The model uses water balance approach and prepares separate water balances for surface and groundwater systems as well as an overall water balance for the basin/sub-basin.

The model is especially useful for assessing future water needs under different scenarios of development and management, and for analyzing impact of different policy options on the state of water availability for an integrated and sustainable use of the resource.

The model can be calibrated making use of data for the past or present conditions for the given basin. Once the model is calibrated, the user can proceed to simulate and analyze alternate scenarios of future development and management of resources. Scenarios can be developed in the model in terms of changes in land use, crop areas under rain-fed and/or irrigated agriculture, cropping patterns, irrigation efficiencies, imports and exports of water, surface (reservoirs) storage, proportion of surface and groundwater withdrawals, etc.

By simulating past conditions of limited water use in the basin, the model can also help the user in setting up minimum reference flows for maintenance and enhancement of river ecology and environment. Comparison of such flows with projected future status of balance river flows can help in setting limits on surface and groundwater withdrawals, including extent of lowering of groundwater tables to meet prescribed "environment flow" requirements. Figure 2 gives a schematic diagram of BHIWA model.

4.2 Assessments for the Selected River Basins

Water assessments for the two sample river basins viz., Sabarmati and Brahmani were carried out using BHIWA model. Figure 3 shows locations of the selected river basins in India. Detailed maps of these river basins are shown in Figures 4 and 5, respectively.
Figure 3 Location of the Sabarmati and Brahmani River Basins
Figure 4  Map of Sabarmati River Basin
Figure 5  Map of Brahmani River Basin
Sabarmati River Basin

Sabarmati River is one of the major west flowing rivers of India. The river basin has a total drainage area of 21,565 km² of which 17,441 km² is in Gujarat and 4,124 km² in Rajasthan.

The per capita water availability in the basin in 2001 was 324 cubic meters per year. This is based on estimated annual renewable water resources of 3810 million cubic meters and population of 11.75 million in the basin. This water availability is the lowest among the river basins of India and much below the generally accepted scarcity norm of 1000 cubic meters per year per person. The per capita water availability is likely to further reduce to about 192 cubic meters per year with the projected population of 19.86 million by 2025.

Agriculture is the dominant land use with forest and ‘land-not-put’ to agriculture use accounting for only about 42% of the basin area. The rain-fed and irrigated agriculture have almost equal share. The annual irrigation from existing major, medium and minor surface water projects¹ is presently of the order of 0.43 million ha. While that from groundwater through public, private tube wells and dug wells is roughly estimated to be a little over 0.70 million ha. Source-wise, groundwater has a major share in terms of area under irrigated agriculture. The present level of irrigation has been made possible mainly through inter-basin transfer of surface waters from the adjacent Mahi River. Additional import from Narmada River has further augmented the supply and more imports are proposed by Gujarat State.

Large Industrial base and urbanisation has added to the water demands. There exist some 20 industrial estates developed by Gujarat State Industrial Development Corporation (GIDC) alone, besides a sizeable number of private industries. There are two thermal power stations in the basin, one in Ahmedabad and another in Gandhinagar. There is a major fertilizer plant of IFFCO in Kalol, falling within the basin area. There is an ample scope and plans for further industrialisation in the basin. The urban population of the basin accounts for about 52 percent of the total as per the 2001 census, which is expected to grow in future and put extra demands for domestic use and sanitation. More than three-fourths of the urban population resides in Ahmedabad-Gandhinagar conglomeration and rise in living standards shall lead to further increase in water demand for D&I use. Even at present, the basin is beset with problems of over-exploitation of groundwater, non-filling of surface water storages, deteriorating of both surface and groundwater quality, social inequity and inter-sectoral conflicts.

The BHIWA Model has been applied to Sabarmati river basin to assess water use under different sectors and their impacts on water availability. The basin was divided into three sub basins. The model was calibrated for the present (1995-2000) conditions and applied to derive responses to past, present and eight alternative scenarios of the future (2025) using long-term average rainfall and assumption of sustainable use. Future scenarios in 2025 could be visualised giving due consideration to possible options of water development and improved management, and propensity of the people in the basin to adapt changes visualised or other compulsions. Apart from Business As Usual (BAsU) scenario (F-I), others examined include scenarios with:

- No Import of water from Narmada basin (F-II);
- Proposal under the future plan of Government of Gujarat (F-III);
- Less import and less export (F-IV);
- Irrigation expansion by seasonal shift of agriculture (F-V);
- Reduction of groundwater use by pumping Narmada waters in the reservoirs (F-VI);
- Reduction of groundwater use by lesser irrigation expansion and better water management (F-VII); and
- Limited shift towards kharif irrigation.

The total water input (rainfall and imports) to the basin is 17,744 million cubic meters. The major output comprises of consumptive use, river flows and exports. The total consumptive use (ET) under the present situation is 14,796 million cubic meters, comprising about 35% by the nature sector (forest, pasture and barren lands), 64% by agriculture sector (rain-fed and irrigated agriculture) and 1% by people (domestic and industrial) sector. The non-beneficial evapotranspiration is about 22% of the total consumptive use. It is seen that out of total consumptive use of irrigated agriculture, 50% is met by rainfall while balance 50% is supplemented through irrigation. The consumptive use for different scenarios (ET) is given in Table 6.

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¹ In India, the connotation of major, medium and minor irrigation projects is based on a categorization. Major: CCA (culturable command area) > 10000 ha, Medium: CCA> 2000 ha < 10,000 ha. and Minor: CCA<2000 ha.
Table 6.
Consumptive Use (ET) By Different Use Sectors in Sabarmati Basin (10^6 m^3)

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<tbody>
<tr>
<td>Nature sector</td>
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<td></td>
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<tr>
<td>Beneficial</td>
<td>3,411</td>
<td>3,410</td>
<td>3,293</td>
<td>3,293</td>
<td>3,293</td>
<td>3,293</td>
<td>3,293</td>
<td>3,293</td>
<td>3,293</td>
<td>3,295</td>
</tr>
<tr>
<td>Non-beneficial</td>
<td>2,475</td>
<td>1,814</td>
<td>1,477</td>
<td>1,478</td>
<td>1,477</td>
<td>1,477</td>
<td>1,477</td>
<td>1,477</td>
<td>1,477</td>
<td>1,456</td>
</tr>
<tr>
<td>Total</td>
<td>5,886</td>
<td>5,224</td>
<td>4,770</td>
<td>4,771</td>
<td>4,770</td>
<td>4,770</td>
<td>4,770</td>
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<td>4,751</td>
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<td>Agriculture sector</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Beneficial</td>
<td>5,091</td>
<td>7,995</td>
<td>10,407</td>
<td>10,411</td>
<td>9,759</td>
<td>9,615</td>
<td>8,085</td>
<td>8,085</td>
<td>7,515</td>
<td>8,402</td>
</tr>
<tr>
<td>Non-beneficial</td>
<td>802</td>
<td>1,447</td>
<td>1,767</td>
<td>1,768</td>
<td>1,691</td>
<td>1,609</td>
<td>1,384</td>
<td>1,448</td>
<td>1,331</td>
<td>1,481</td>
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<tr>
<td>Total</td>
<td>5,893</td>
<td>9,442</td>
<td>12,174</td>
<td>12,179</td>
<td>11,450</td>
<td>11,224</td>
<td>9,469</td>
<td>9,533</td>
<td>8,846</td>
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<td>People Sector</td>
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<tr>
<td>D&amp;I</td>
<td>54</td>
<td>130</td>
<td>575</td>
<td>575</td>
<td>575</td>
<td>575</td>
<td>575</td>
<td>575</td>
<td>575</td>
<td>575</td>
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<tr>
<td>Total</td>
<td>11,833</td>
<td>14,796</td>
<td>17,519</td>
<td>17,525</td>
<td>16,795</td>
<td>16,569</td>
<td>14,814</td>
<td>14,878</td>
<td>14,191</td>
<td>15,209</td>
</tr>
</tbody>
</table>

A similar comparison of monthly river flows at the basin outlet is provided in Table 7 to help visualise the overall impacts of changing land and water management on availability.

Table 7.
Monthly River Flows in Different Scenarios in Sabarmati Basin (10^6 m^3)

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<tbody>
<tr>
<td>June</td>
<td>7</td>
<td>0</td>
<td>55</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>157</td>
<td>0</td>
<td>91</td>
<td>5</td>
</tr>
<tr>
<td>July</td>
<td>663</td>
<td>383</td>
<td>352</td>
<td>22</td>
<td>408</td>
<td>293</td>
<td>901</td>
<td>847</td>
<td>899</td>
<td>286</td>
</tr>
<tr>
<td>August</td>
<td>2,307</td>
<td>2,103</td>
<td>532</td>
<td>130</td>
<td>1,082</td>
<td>939</td>
<td>2,067</td>
<td>2,153</td>
<td>2,848</td>
<td>1,570</td>
</tr>
<tr>
<td>September</td>
<td>467</td>
<td>102</td>
<td>169</td>
<td>-149*</td>
<td>267</td>
<td>171</td>
<td>547</td>
<td>865</td>
<td>550</td>
<td>324</td>
</tr>
<tr>
<td>October</td>
<td>308</td>
<td>-37*</td>
<td>94</td>
<td>-78*</td>
<td>77</td>
<td>3</td>
<td>59</td>
<td>-34*</td>
<td>78</td>
<td>207</td>
</tr>
<tr>
<td>November</td>
<td>206</td>
<td>-44*</td>
<td>68</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>13</td>
<td>-22*</td>
<td>31</td>
<td>7</td>
</tr>
<tr>
<td>December</td>
<td>134</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>9</td>
<td>9</td>
<td>5</td>
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<tr>
<td>January</td>
<td>73</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>56</td>
<td>38</td>
<td>21</td>
<td>5</td>
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<tr>
<td>February</td>
<td>63</td>
<td>65</td>
<td>31</td>
<td>35</td>
<td>0</td>
<td>48</td>
<td>76</td>
<td>62</td>
<td>52</td>
<td>48</td>
</tr>
<tr>
<td>March</td>
<td>46</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>22</td>
<td>45</td>
<td>14</td>
<td>13</td>
<td>100</td>
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<td>0</td>
<td>15</td>
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<td>May</td>
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<td>22</td>
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<td>0</td>
<td>2</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>92</td>
</tr>
</tbody>
</table>

* This denotes small negative flow (which are not possible) and resulting from limited iterations available in the programme.
Brahmani River Basin

Brahmani River is one of the east flowing rivers of India. The basin has total drainage area of 39,268 km² of which 22,516 km² is in Orissa State, 15,405 km² in Jharkhand State and 1,347 km² in Chhattisgarh State.

The per capita water availability in the basin in 2001 was 2,595 cubic meters per year considering the estimated annual renewable water resources of the basin at 21,920 million cubic meters per year and the population of the basin at 8.457 million. The per capita water availability is likely to be further reduced to 1343 cubic meters per year with the projected population of 16.36 million by 2025.

The people of the basin mainly depend on agriculture and on forest produce. The gross cultivated area under agriculture is 1.575 Mha of which 1.237 Mha is under rain-fed and remaining area is irrigated. The irrigation development in the basin is not very large. Orissa State has proposed to bring an additional area of 0.45 Mha through major and medium schemes and 0.12 Mha from minor irrigation schemes. Jharkhand state has proposed to have a total irrigation of 0.56 Mha from major and medium schemes and 0.10 Mha form minor schemes. Chhattisgarh State has proposed to have irrigation potential for an area of 0.002 Mha from minor irrigation. The basin has abundant mineral resources such as iron ore, coal and limestone. Rourkela Steel Plant built in 1960 is one of the large steel plants with substantial ancillary industries.

In the Angul-Talcher area, there are two large thermal plants established by National Thermal Power Corporation and National Aluminium Company, besides coal based fertilizer plants set up by the Fertilizer Corporation of India. Industrial activity in Jharkhand is also picking up substantially. The basin is rich in forest occupying 37% of the basin area. The Bhitarankika National Park and Bhitarankika wild Life Sanctuary are located near the Brhamani-Baitharani delta. About 215 sq.km. of the mangroves in this region has been listed as RAMSAR SITE in November 2002. The basin has a considerable potential for development of Inland fisheries in reservoir, ponds, tanks and canals. The occurrence of floods, particularly in the deltas is a common feature and on an average annually a population of 0.6 million and crop production of over 50,000 ha in the delta is affected. The Rengali storage has provided some relief in this regard but has not eliminated the problem.

The Basin-wide Holistic Integrated Water Assessment (BHIWA) Model has been applied to this water-rich river basin to assess impact of change in land and water use by different sectors under the past, present and four alternative scenarios of the future (2025). The basin was divided into four sub-basins. The model was calibrated for the present (1997-1999) conditions and applied to derive responses for an average year and conditions of sustainable water use. Future scenarios were visualised giving due consideration to rural population base and its dependence on agriculture for livelihood as also the present status and possible growth of industries and requirements of maintaining minimum flows from navigation and environment perspective, etc. Apart from Business as Usual Scenario (F-I), other scenarios examined include:

- With greater emphasis on expansion of agriculture and irrigation (F-II);
- With increased emphasis on industrialisation (F-III); and
- With lesser growth of irrigated agriculture and industry (F-IV) as well as in-stream flow requirements for environment and navigation in the lowermost reaches of Brahmani.

The aggregated results of the study and discussions of the results of the Brahmani basin assessment are presented in the basin report.

The total water input (rainfall and imports) to the basin in the present situation is 51,586 million cubic meters. The major output comprises of consumptive use (69%) and river flows (31%). The total consumptive use (ET) at present situation is 34,138 million cubic meters comprising about 64% by Nature sector (forest, pasture and barren lands), 35% by agriculture sector (rain-fed and irrigated agriculture) and 1% by people sector (domestic and industrial). The non-beneficial ET is about 28% of the total consumptive use. The sectoral consumptive use for past, present and under different scenarios of the future and its composition is given in Table 8.

A comparison of rivers flows to sea is presented in Table 9 to help visualise impacts of the changing land use and choices of water development and improved management on availability.

4.3 Extrapolation to Other Indian Basins

In order to understand the characteristics of water availability and water use in other major river basins, indicators were chosen to compare their relative values. Data from secondary sources, including the report of the National Commission on Integrated Water Resource
### Table 8.
Consumptive Use (ET) by Different Use Sectors in Brahmani Basin (10^6 m³)

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<tr>
<td></td>
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<td>F-I BAU</td>
<td>F-II</td>
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<tr>
<td>Nature sector</td>
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<tr>
<td>Beneficial</td>
<td>15,948</td>
<td>16,223</td>
<td>16,223</td>
</tr>
<tr>
<td>Non-beneficial</td>
<td>8,424</td>
<td>4,684</td>
<td>3,703</td>
</tr>
<tr>
<td>Total</td>
<td>24,372</td>
<td>20,907</td>
<td>19,926</td>
</tr>
<tr>
<td>Agriculture sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beneficial</td>
<td>5,819</td>
<td>9,380</td>
<td>10,498</td>
</tr>
<tr>
<td>Non-beneficial</td>
<td>1,803</td>
<td>5,740</td>
<td>5,889</td>
</tr>
<tr>
<td>Total</td>
<td>7,622</td>
<td>15,120</td>
<td>16,387</td>
</tr>
<tr>
<td>People sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D&amp;I</td>
<td>72 (0)</td>
<td>333 (1%)</td>
<td>333 (1%)</td>
</tr>
<tr>
<td>Grand Total</td>
<td>32,066</td>
<td>36,360</td>
<td>36,646</td>
</tr>
</tbody>
</table>

Figures in parenthesis show percentage of the grand total.

### Table 9.
Monthly River Flows in Different Scenarios in Brahmani Basin (10^6 m³)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F-I BAU</td>
<td>F-II</td>
</tr>
<tr>
<td>June</td>
<td>1,615</td>
<td>672</td>
<td>553</td>
</tr>
<tr>
<td>July</td>
<td>4,454</td>
<td>2,293</td>
<td>2,194</td>
</tr>
<tr>
<td>August</td>
<td>6,677</td>
<td>4,473</td>
<td>4,414</td>
</tr>
<tr>
<td>September</td>
<td>3,793</td>
<td>1,261</td>
<td>1,230</td>
</tr>
<tr>
<td>October</td>
<td>1,408</td>
<td>1,483</td>
<td>1,475</td>
</tr>
<tr>
<td>November</td>
<td>681</td>
<td>1,473</td>
<td>1,457</td>
</tr>
<tr>
<td>December</td>
<td>362</td>
<td>970</td>
<td>970</td>
</tr>
<tr>
<td>January</td>
<td>209</td>
<td>725</td>
<td>741</td>
</tr>
<tr>
<td>February</td>
<td>132</td>
<td>626</td>
<td>647</td>
</tr>
<tr>
<td>March</td>
<td>91</td>
<td>375</td>
<td>402</td>
</tr>
<tr>
<td>April</td>
<td>28</td>
<td>533</td>
<td>542</td>
</tr>
<tr>
<td>May</td>
<td>64</td>
<td>337</td>
<td>307</td>
</tr>
<tr>
<td>Total</td>
<td>19,515</td>
<td>15,220</td>
<td>14,933</td>
</tr>
</tbody>
</table>
Development Plan (NCIWRDP) and the past estimates of Central Water Commission (CWC). Large heterogeneous basins like the Ganga, the Godavari etc. had to be treated as single units for want of data.

**Water Situation Indicators (WSI)**

A quick survey of water stress indicators (we prefer to call them as water situation indicators) used in international literature, such as those suggested by Alcamo et.al (2002), Smakhtin et.al (2002) was made.

As per Alcamo et.al, the water stress Indicator (WSI) is defined as follows:

\[
WSI = \frac{\text{Withdrawal}}{\text{Mean Annual (natural) Runoff (MAR)}}
\]

Smakhtin et.al, suggested a modification to account for water use for maintaining ecology and environment:

\[
WSI = \frac{\text{Withdrawal}}{\text{(MAR – Environmental water requirement for aquatic Eco-system)}}
\]

At the 3rd World Water Forum (2003), ICID suggested the following relationship:

\[
WSI = \frac{\text{Withdrawal}}{\text{(MAR – Society’s need for food, people and nature as evidenced by consumptive use)}}
\]

The following four indicators are proposed in the modelling framework used in detailed assessment for the purposes of describing pressure on resources due to withdrawals and threat to water quality.

Indicator 1: Withdrawals/ Total input to surface water
Indicator 2: Returns/ total input to surface water
Indicator 3: Withdrawals/ total input to groundwater
Indicator 4: Returns/ total input to groundwater

These indicators have been considered more relevant to Indian situation due to the following reasons.

1. There is a large groundwater use in India. One needs indicators, which reflect water uses from both surface and groundwater sources.
2. The WSI as defined based on ‘withdrawals’, out of which a substantial part may return. Either one needs to consider the returns as an additional resource, adding to the natural runoff, or, one needs to consider the ‘net consumptive use’ rather than withdrawals.
3. The change suggested by Smakhtin et.al presupposes that the environmental water flow requirement for aquatic eco-system has an overriding priority, and only the rest of the water flow is available for any use for terrestrial natural eco-systems, food or people. This does not appear appropriate for many basins that are water-deficit or at a threshold level. The in-stream environmental uses is in terms of flow requirements and is not consumptive use as in other cases and can instead be considered as one of the requirements, competing with others. It just provides a habitat and remains un-consumed till it reaches the ocean.
4. The methodology for computing the pseudo natural mean annual runoff (MAR) by considering the withdrawals and returns has not been explained by Alcamo and Smakhtin. Since large land use changes can also affect the natural supply, this becomes more complex. Either a ‘natural’ land use, which does not allow for human interventions through agriculture, or a ‘pseudo-natural’ condition, where agriculture is allowed but irrigation is not, would have to be defined for this purpose. In the present study “past” conditions were simulated as these may correspond to a ‘pseudo-natural’ condition.

Instead of basing the indicator on gross withdrawals (numerator) and gross inputs (including human induced returns), these could also have been based on the net consumption (numerator) and the natural inputs (under the pseudo-natural conditions, without human interventions other than land use modification) in the denominator.

The proposed indicators have been used to depict the water situations in the basins in quantitative as well as qualitative terms. Indicators 1 and 3 depict the level of withdrawals as fractions of total water available in surface and groundwater system, respectively. While indicators 2 and 4 depict the potential hazards to water quality in surface and ground water systems, respectively.

The indicators were sub divided into 4 categories each to represent the degree of water stress as given in box 1:

Approximate values of water indicators were computed for the present conditions in respect of other Indian basins and compared with those derived through detailed assessments for sample basins.

Grouping of various Indian River basins was attempted based on the foregoing criteria and values of water situation indicators, and results are presented in table 10.
Box 1.
Categories of surface and groundwater indicators

(a) Indicator 2 - Surface water quality
1. Very high stress – value of indicator more than 0.8
2. High stress – value of indicator between 0.4 and 0.8
3. Moderate stress – value of indicator between 0.2 and 0.4
4. Low stress – value of indicator less than 0.2

(b) Indicator 2 - Surface water quality
1. Very high threat – value of indicator more than 0.8
2. High threat – value of indicator between 0.2 to 0.8
3. Moderate threat – value of indicator between 0.05 and 0.2
4. Low or no threat – value of indicator less than 0.05

(c) Indicator 3 - Groundwater withdrawals
1. Very high stress – value of indicator more than 0.8
2. High stress – value of indicator between 0.4 and 0.8
3. Moderate stress – value of indicator between 0.2 and 0.4
4. Low stress – value of indicator less than 0.2

(d) Indicator 4 - Groundwater quality
1. Very high threat – value of indicator more than 0.8
2. High threat – value of indicator between 0.2 to 0.8
3. Moderate threat – value of indicator between 0.05 and 0.2
4. Low threat – value of indicator less than 0.05

Table 10.
Grouping of River Basins by Water Situation Indicators

<table>
<thead>
<tr>
<th>Class description</th>
<th>Value of indicator</th>
<th>Basin(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very highly stressed through surface withdrawal</td>
<td>&gt;0.8</td>
<td>Pennar</td>
</tr>
<tr>
<td>Highly stressed, through surface withdrawal</td>
<td>0.4 – 0.8</td>
<td>Cauvery</td>
</tr>
<tr>
<td>Moderately stressed, through surface withdrawal</td>
<td>0.2 – 0.4</td>
<td>Indus, Ganga, Subarnarekha, Mahanadi, Tapi, Sabarmati</td>
</tr>
<tr>
<td>Low stress, in regard to surface withdrawal</td>
<td>&lt;0.2</td>
<td>Brahmaputra, Godavari, Brahmani</td>
</tr>
<tr>
<td>Indicator 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface water quality, low stress</td>
<td>&lt; 0.05</td>
<td>All basins</td>
</tr>
<tr>
<td>Surface water quality, moderate stress</td>
<td>0.05 – 0.2</td>
<td>Cauvery, Tapi, Sabarmati, Pennar</td>
</tr>
<tr>
<td>Indicator 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater very highly stressed through withdrawals</td>
<td>&gt;0.8</td>
<td>Sabarmati</td>
</tr>
<tr>
<td>Groundwater highly stressed through withdrawals</td>
<td>0.4 – 0.8</td>
<td>Indus, Ganga, Subarnarekha</td>
</tr>
<tr>
<td>Groundwater moderately stressed</td>
<td>0.2 – 0.4</td>
<td>Mahanadi, Godavari, Krishna, Pennar, Cauvery, Tapi, Narmada, Mahi</td>
</tr>
<tr>
<td>Ground water low stressed</td>
<td>&lt;0.2</td>
<td>All other basins including Brahmani</td>
</tr>
<tr>
<td>Indicator 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater quality under very high threat</td>
<td>&gt;0.8</td>
<td>None</td>
</tr>
<tr>
<td>Groundwater quality under high threat</td>
<td>0.4 – 0.8</td>
<td>Indus, Ganga, Subarnarekha, Krishna, Pennar, Cauvery, Sabarmati</td>
</tr>
<tr>
<td>Groundwater quality under moderate threat</td>
<td>0.2 – 0.4</td>
<td>Brahmaputra, Mahanadi, Godavari, Tapi, Narmada, Mahi, Brahmani</td>
</tr>
</tbody>
</table>
Thus, the policy issues in regard to increasing use of and stress on the waters emerging out of the Sabarmati river basin studies would be of relevance to the river basins of Pennar, Cauvery, Indus, Ganga, Subarnarekha, Mahanadi and Tapi in regard to surface water. In regard to groundwater quality also the problems of Indus, Ganga, Subarnarekha, Krishna, Pennar and Cauvery would be similar to Sabarmati. On the other hand, some problems of the Brahmani river basin are attributable to high river flows and low use of groundwater. Brahmaputra, Godavari, Mahanadi, Tapi, Narmada and Mahi river basins are likely to have similar groundwater related problems, where policies to increase groundwater withdrawals in future may be necessary.
CHAPTER 5

POLICY ISSUES EMERGING FROM ASSESSMENTS

The detailed hydrologic modelling and analysis of past, present and various scenarios for the future for the two sample basins have provided a better understanding of the water resources and human impacts in these basins. The holistic view of the assessments taken through the modelling gives a sound and much broader basis to describe the state of water availability and likely water use under different sectors and various future scenarios at the basin/sub-basin level, source-wise – surface and ground water separately and interaction between the two. Modelling has been used to develop a set of indicators, which help in understanding the current water scene for other basins of India. More importantly, the comprehensive modelling framework developed under CPSP has allowed the testing of various policy options and possible scenarios of the future land and water use including their hydrologic implications. Policy related issues emerging from the key findings of these studies are described in the following paragraphs:

Need for a Shift in the Concept of “Water Resources”

Traditionally, the natural river flow and natural recharge to groundwater are together considered to constitute the total renewable annual natural water resource of a basin. However, the river runoff is the residual water and it is subject to change because of large changes brought about by the land and water use in the basin. It was therefore felt that rainfall (or precipitation), which is the primary source of all waters on land, should be considered as the primary renewable water resource. The approach used by the National Commission on Integrated Water Resources Development Plan (NCIWRDP) had taken into account the ‘utilisability’ factor by considering constraint of reservoir storages on use of surface waters. The NCIWRDP also considered the additional availability of water due to return flows out of the withdrawals from surface and groundwater bodies. It constituted an improvement over the traditional view. The concept however required further improvement to take into account the following:

(i) While the average precipitation is, more or less, a stationary process (except for the effect of climate change), the conversion of precipitation into runoff is the result of a non-stationary process, largely governed by anthropogenic changes in land use.

(ii) The water use technologies are changing under the water stressed situations. While, earlier, water management was limited to the management of surface or groundwater, the direct and local use of rainfall, or the management of evapo-transpiration is now being practiced, and such techniques would become increasingly important.

(iii) An integrated and holistic understanding of the resources, and their uses from different phases of the anthropogenically modified hydrologic cycle, for different use sectors like nature, food and people, requires that the whole land phase of the hydrologic cycle be quantified.

The BHIWA model evolved and tried in CPSP studies attempts to account these effects.

Accounting Water Use by the Sector, and Integration

Water use by ‘nature’ includes actual consumptive use (evaporation needs) of the lands and the vegetation supporting the natural eco-system and are derived from rain, soil moisture and partly from groundwater storage. Similarly, agriculture use consists of actual evapo-transpiration from rain-fed lands and the additional ET needs of irrigated lands that are met through irrigation.
The ET from agricultural lands during the period in between crop rows also needs to be clubbed with the water use in the food sector. The consumptive uses of individual sectors are to be assessed and integrated to study impacts of land use policies, and determine withdrawals, requirements for irrigation, domestic and industrial use and considering the innovative trends in water use efficiency.

So far, the uses by different sectors i.e. nature, people and food are considered as separate/stand alone entities. However, some of the uses are partly overlapping, while some are not. For example,

- In regard to acting as CO₂ sinks, the role of new/additional biomass created by irrigation or food sector is compatible with the water use by nature sector, in forests, grasslands and wetlands.
- To the extent that a well managed and preserved forest sustains livelihood to village communities through gathering forest products, commercial exploitation of timber in a sustainable way, support to eco-tourism etc., the water use for nature is compatible with the water use for food sector.
- Similarly, riverine aquatic fisheries are compatible with both nature and food sectors.
- Outflows from hydropower storages, if not used for irrigation (food sector), could be compatible with riverine and estuarine needs of nature sector, as also with the navigational use of people sector.
- Riverine and estuarine water needs of nature sector could be partly compatible with the navigational water needs of the people sector.

Thus, improving water use in one sector could also often benefit other sectors, and this needs to be considered in deciding individual use and integrated water requirements including trade-offs between various uses.

Proper Accounting of Return Flows

The return flows from both point and non-point sources, constitute a sizable resource but could be of different qualities, depending on the water management by each use sector. They indicate potential pollution hazard, if not treated before allowing entry into river flows. Prior-treatment is a must for availing this resource as well as for protection of water quality in the down-stream. Luckily, the treatment for point source return flows, which constitutes a major proportion of return flow, is easier, legally enforceable with enabling acts and enough monitoring mechanism equipped with standards to be assured. Special effort is called for converting all non-point polluted returns to point sources for facilitating treatment.

Till then, the proportion of returns in the total quantum of surface / ground waters, would be a simple indicator of the pollution hazard. This is a lumped indicator. For example, in surface flow system, the input from rainfall may be 100 units, and the withdrawal may be 50 units, of which 20 may return. This situation would indicate a value of the hazard index of 20 / 120. This would be a fair indicator provided withdrawals and returns are spatially well distributed in the basin. However, if all withdrawals were from the near pristine sources in the upper part of the basin, 20/70 would be a better indicator.

Consumptive Use (ET) Management

The consumptive use (ET) management is to be treated as an integral part of water and land related resources management.

In each use sector, there can be efficient or inefficient uses. They can be also considered as productive/non-productive, beneficial/non-beneficial from human system point of view. In nature sector, while ET from forests or grasslands would fulfil the need of sustaining flora and fauna in that ecosystem, acting as carbon dioxide sinks for atmospheric pollution etc, ET from wastelands may have comparatively less ‘utility’, particularly where these uses are patchy. Some environmentalists consider the very small water consumption in deserts as essential for eco-system. Through proper control of the vegetative growth of bushes and grasses in the wastelands, the ET component in the nature sector could be reduced. In this study, goods and services provided by the nature systems for human systems are considered as an indicator for water need.

In the agriculture (food) sector, the reduction of evaporation through mulching, using plastic sheets, or dry grass, crop residues, creation of moist microclimates etc., is possible. The model adopted is capable of studying the hydrologic implication of these, and such policy options can be considered. In irrigated agriculture, use of micro-irrigation, that do not wet the land strips between rows of plants, provides a method for reduction of non-beneficial ET proportion.

Watershed Management and Development (WSM &D) through Rainwater/runoff Harvesting at Various Scales

Watershed management which modifies the natural distribution of available water, between surface and
groundwater i.e. quantum of natural recharge to ground water and quick-flow to streams, is again a policy option for balancing water use, which can be studied through BHIWA model, once we start with rainfall as resource. Management of a river basin, sub-basin, stream catchment or going down up to a micro watershed all encompass WSM&D. All these need to be considered in a holistic & integrated manner. For example, sometimes, in terms of the cost per unit of water to be diverted, the watershed development maybe costlier compared to large storages. On the other hand, this option may be the only one available to local upland areas, and also, it may have lesser social costs. Balancing such consideration is a part of IWRDM.

WSM&D enables a more equitable use of land and water and often involves harvesting (use) of the rainwater, at the place of its occurrence (or in immediate vicinity). The use itself can be through small storages on the field (as in the paddies and farm ponds) or in a rivulet, where it acts as a ponded miniature storage, or by inducing recharge into groundwater, for use further downstream. The latter allows further time shifts between availability and use. Further, when stored as groundwater, availability is augmented, evaporation is avoided.

WSM&D can conserve only a part of the rainfall. Even on sloping lands, fully covered with contour bunds, the average additional storage would hardly exceed 15 to 20 centimetres in depth and in normal rain events, runoff would occur. Such measures are relatively costly, and can cover only small-prioritised part of the watershed. Thus, while local measures of watershed management and rainwater harvesting can augment utilizable water, there is a significant limitation of such measures in eliminating basic water scarcity that stems from rainfall. Construction of medium and large surface water based schemes allows transfer and redistribution of water resources at a larger temporal and spatial scales and offers additional opportunities of hydro-power generation, water supplies for urban towns and cities and industry, among others. While minor schemes and local measures can help to meet part of local requirements, they cannot help in eliminating disparities arising out of skewed distribution of land, water and population and should not be viewed as substitutes of larger schemes. There is thus enough scope for all types of water development from micro to mega for a basin scale.

The effect of such micro level WSM&D on the downstream availability would be seen better due to the holistic nature of BHIWA model evolved under CPSP programme. In the conventional concept, which uses river flow as a resource, rainwater harvesting cannot be appropriately accounted.

The Sabarmati studies throw up an interesting issue about WSM&D. Most reservoirs like Dharol, Hathmati etc. did not fill up even to half their capacity in several years since construction. This could be due to inadequate assessments, large-scale water use in the catchment (including groundwater development), large water use in kharif, or pumping during the filling period etc. If, in these catchments, further WSM&D and use of water in the upstream takes places, the reservoir storage and downstream use will further reduce. The conflict arising out of policies encouraging all types of actions in the watershed and basin in which storages existed and development based on storages took place is obvious and the need for a holistic approach comes to the fore.

Two policy related issues come up from this finding.

- When planning storage schemes, the possibilities of upstream developments, including WSM&D, minor irrigation schemes etc. need to be carefully examined and projected. The reservation (or lack) thereof as made needs to be well publicized and it needs to be discussed in the public hearings. Some of the hearings could be held in the catchment area, so that the people who would be losing their options of future development beyond the reservations, due to the existing downstream project, could be made aware of the situation.

- In catchments of projects in which such problem of non-filling of reservoirs is experienced, WSM&D has to be effectively discouraged, in order not to cause any further reduction in water availability and waste of public investment already made. This may appear unduly harsh to the potential users in upper regions, but since the lower region use has been materialized earlier, protection will have to be given to that use. This policy would be somewhat akin to that about discouraging further groundwater development in an already over exploited block. Thus, without encroaching on the rights of the landowners to harvest water, the WSM&D through public funds on loans could be restricted in these areas.

Integrating Surface Water and Groundwater Use in Irrigation

Much has already been said, in various policy documents, about conjunctive use of surface and
groundwater in surface water irrigated areas. Planning for groundwater use in arable areas, which can’t be supplied through surface water irrigation, is also necessary, since it affects the water availability in the surface system. Such use is also considered for people sector. Groundwater could be effectively used for nature sector in estuarine areas.

Both the Sabarmati and Brahmani basin studies brought out the need for attaining a desirable mix of surface and groundwater used for irrigation.

In Brahmani basin, the studies indicate that surface irrigation development on a larger scale as projected through Rengali dam would tend to cause an increase in recharge, which will be much larger than groundwater withdrawals, thus disturbing the groundwater balance and causing groundwater to rise, until, because of larger gradients, base flows increase to help regain the dynamic balance of the river flows. In some areas, this could lead to waterlogging. This is already reported in deltaic areas. Unless, preventive steps are taken this will lead to an unsustainable development situation.

Individual farmers might be unwilling to increase groundwater irrigation because (i) it requires much larger capital and O&M expenditure, and (ii) abundant surface water availability would discourage it.

The policy interventions, (INCID, 1993) useful for such basins are:

- Subsidize groundwater exploitation in such areas and increase surface water prices. Equalization need not be attempted, since groundwater use, and the management control remain in the hands of the user and hence, has a larger intrinsic value to the user.
- Charge the Water Users Association (WUA) with responsibilities for groundwater monitoring and management. Provide for reduction in surface supplies to a WUA if, in its area, ground waters are rising.
- Under-design the distribution system: In planning and design exercises, purposefully undersize the surface distribution, and in particular, do not cater to sharp peaks in water demands for one or two ten-day periods. These would in practice, get damped or smoothened through the normal staggering of farm operations. Even if these occur, a part of the peak demand can be met by groundwater.

In Sabarmati, the problem is reverse. Almost 70% of the current irrigation use is through groundwater. Groundwater withdrawals are much larger than irrigation induced recharge. In some areas, they appear to be larger than the total input, thus indicating non-sustainable use. The problem is how to reduce the groundwater use. Unless reliable surface supplies could be provided, groundwater use cannot be reduced.

Rules were made for restricting groundwater exploitation beyond a particular depth. But these were ineffective. It is clear that while restrictions on future uses may be possible, curtailment of established uses would be very difficult and solutions to stabilize the situation, such as water imports, artificial recharge may become the only acceptable options. But even after this, the tendency to overexploit groundwater may continue unless pricing for pumping power is raised substantially and/or recovery of dues is strictly enforced.

Cutting off the electricity supplies to WUA when they allow groundwater levels to decline, appears too harsh, since in short run, farmers would be left high and dry. However, community actions, which look beyond short-run gains for individuals, and facilitating promotion of actions by younger generation for whom, future for water is at stake, may help.

**Integrated Management of Land and Water Resources**

The land parcel based working, and the flexibility it allows has highlighted the need for integrating the land and water resources in planning. It is well known that in the traditional sense where river flows and the groundwater are the recognized resources for irrigation and agriculture sector would continue to be the predominant user. Even while considering precipitation as the resource, land based ET becomes the predominant user as compared to non-land related uses for municipal, domestic and industrial purposes. Navigation and its flow needs are exceptions.

Although the principle is well known, planning of irrigation projects in a river basin largely does not integrate rain-fed lands or lands holding promise of seasonal irrigation in the command. The production from land put to other uses is also often not integrated. Similarly, reduction in wasteland is not integrated in irrigation planning.

The Sabarmati basin studies have brought out the importance of appropriate choice of a cropping pattern with seasonal water requirements matching the availability, so that agricultural water use does not deplete the available
resources in an unacceptable way. Implementing such planning, as also rain water harvesting and its compatibility with water management would require changes in institutional management, by creating a forum for a joint look at the land, environment and water related sectors.

**Integrating Livelihoods in Land and Water Planning**

Macro planning for food through irrigated agriculture, as has been envisaged by the NCIWRDP (1999) examines if enough land and water is available in India to produce all the required food through irrigation and rain-fed agriculture. A similar exercise in smaller areas like states or basin would also answer the same question. While self-sufficiency in food, for the nation as a whole would be a desirable goal, self-sufficiency in smaller units is not a policy objective. Various recent policy statements promote the notion of a single nationwide market with measure like creation of mandi* system, electronic and media publicity of mandi prices, introduction of Agricultural Produce Marketing Cooperatives etc in many States.

In the current planning, the need for providing in-situ livelihood to the rural population is perhaps not addressed. By 2025, 40% of India may be urbanised. Of the remaining 60% about a quarter could derive livelihood from services and small industries sector in the rural setting, but 45% of the population may have to derive the main livelihood from agriculture. For these 540 million persons, deriving livelihood from a net sown area of about 150 million ha (and a gross cropped area of about 220 million ha, including a GIA of about 120 million ha) is a challenge. For low rainfall regions with considerably high rural population density, (in areas similar to Sabarmati basin) this could become very important, as illustrated in Table 11 & 12. The assumptions made are shown in Table 13.

Out of the total runoff of 175,000, use of local runoff from agricultural lands, of say 45,000 m³/yr, may be possible. This will irrigate 15 ha at the rate of 300 mm. Runoff from adjoining non-agricultural lands may be assumed as 85,000 m³/yr. Using part of this through minor irrigation schemes will add another 15 ha, providing irrigation for 30 ha at most.

The broad estimate of the per capita income of agriculture dependent rural population in such a typical area is shown in the Table 12.

Poverty due to high population densities beyond the normal carrying capacities of the land can be alleviated only marginally through rainwater harvesting and local minor irrigation schemes. But, for a substantial enhancement of welfare and reduction or elimination of poverty, large-scale irrigation has to be articulated. (Large irrigation schemes possible through non-local water use could further improve incomes by allowing conversion of some barren lands in to irrigated lands, as also by allowing diversified dry season irrigation of higher value crops).

The analysis of the situation which emerge from the illustration, indicates that

- In low rainfall plain areas with sizable population densities, the carrying capacity of the area, in terms of rural livelihoods, is severely constrained by local water availability,
- Water from outside, either from wetter part of the basin or other basins would have to be applied to the land to increase this carrying capacity,
- Even if self-sufficiency in food is not targeted, food would have to be produced for generating local incomes, and for avoiding migrations,
- Integration of water, land and livelihoods is essential.

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* Mandi is the local term used for market where farmers sell their agricultural produce.
The NWP accords drinking water the highest priority. The Apex court in India, through, case law, has established that access to good quality raw drinking water part of the fundamental right to life. The Sabarmati basin study in particular, has pointed out that the dimension of this priority needs to be refined and defined. This can include the following aspects:

- The ‘drinking water’ is a very small requirement, since the actual drinking need of humans is only 3 to 5 litres/day. A larger core demand for drinking, cooking and essential health and hygiene, at about 50 litres/day also needs to attract the highest priority. Non-core municipal demands can be on a somewhat lower priority.
- The priority to be accorded during planning needs to be defined as follows:

| Table 12. Estimate of Per Capita Income from Typical 1 km² Low Rainfall Rural Area in India |
|---|---|---|---|---|---|---|---|---|---|
| | Rain-fed area (ha) | Irrigation intensity | Net irrigated area (ha) | Total Production (tons) | Value @ Farm gate price (Rs.) | Net farm income (Rs./yr) | Net farm per capita (Rs./yr) | Net total income (Rs./yr) | Net total income US$/day |
| Alternate 1 | Rain-fed agriculture | 60 | 1.0 | 0 | 75 | 525,000 | 315,000 | 3,000 | 3,600 | 0.22 |
| Alternate 2 | Rain water harvesting | 45 | 1.0 | 15 | 101 | 708,750 | 425,250 | 4,050 | 4,860 | 0.30 |
| Alternate 3 | Small irrigation with local water | 30 | 1.0 | 30 | 128 | 892,500 | 535,500 | 5,100 | 6,120 | 0.37 |
| Alternate 4 | Full irrigation with outside water | 0 | 1.3 | 60 | 234 | 1,638,000 | 982,800 | 9,360 | 11,232 | 0.68 |

Table 13. Assumptions from Computation of Income in Table 12

<table>
<thead>
<tr>
<th>Assumptions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural population density per km²</td>
<td>150</td>
</tr>
<tr>
<td>% dependent on agriculture</td>
<td>70</td>
</tr>
<tr>
<td>Rain fed yield, t/ha</td>
<td>1.25</td>
</tr>
<tr>
<td>Irrigated yield, t/ha.</td>
<td>3</td>
</tr>
<tr>
<td>Farm gate price Rs./kg.</td>
<td>7</td>
</tr>
<tr>
<td>Net farm income as % of production value</td>
<td>0.6</td>
</tr>
<tr>
<td>Additional income from allied activities as % of net farm income</td>
<td>20</td>
</tr>
<tr>
<td>Conversion (Rs/US$)</td>
<td>45</td>
</tr>
</tbody>
</table>

Water for People: Dimensions of Priority

The NWP accords drinking water the highest priority. The Apex court in India, through, case law, has established that access to good quality raw drinking water part of the fundamental right to life. The Sabarmati basin study in particular, has pointed out that the dimension of this priority needs to be refined and defined. This can include the following aspects:

- The ‘drinking water’ is a very small requirement, since the actual drinking need of humans is only 3 to 5 litres/day. A larger core demand for drinking, cooking and essential health and hygiene, at about 50 litres/day also needs to attract the highest priority. Non-core municipal demands can be on a somewhat lower priority.
- The priority to be accorded during planning needs to be defined as follows:

Water Allocation by Uses

Currently, allocations of waters of an interstate river basin between party’s states are made as allocation to the state. It would call for appropriate investment infrastructure for developing and utilising the water. This negates the principle of water as a “negative community”. It also leaves scope for a State to plead for allocation for high priority uses but to actually deploy it on a low priority use because of exigencies. Allocation of waters for the ‘people sector’ is likely to suffer in the process. Allocation to states could include some earmarked allocations for particular sector/priority need.

Urban & Rural Water Supply & Sanitation

- It is seen that in most urban areas preference is given for laying the water supply system in new developments and the same is also commissioned, without laying the sewerage system for collection of waste water and its treatment and disposal, and causing unhygienic conditions. Thus there is severe backlog of sewerage system. For future, it should be
made mandatory that approval of a water supply development project for a new area, and release of funds is subject to taking up of the project for sewerage system also for collection of wastewater, treatment and disposal, simultaneously. For existing schemes, priority for wastewater collection, evacuation and treatment should be assigned. Public-Private-Partnership (PPP) could be encouraged to play a major role, particularly to meet Millennium Development Goals (MDG) to ensure water supply and sanitation for population in developing countries.

- In mega and metropolitan cities, greater emphasis needs to be given to decentralization of sewage treatment facilities, wherever feasible, with arrangement for utilization of treated effluent.
- ICID has a special Work Team on Use of Poor Quality of Water for Irrigation (WT-PQW), which inter-alia is evolving and updating guidelines on management of poor quality waters for irrigation including saline and brackish water. The use of effluent from sewage treatment plants for irrigation, horticulture and industrial cooling should be maximized, thereby saving precious water for augmenting water supply. This will be done in such a way that the health norms are duly taken care of.
- In large urban areas where there is acute scarcity of drinking water, wastewater from kitchen, bathroom sullage should be collected separately and treated suitably for re-circulation.
- Water auditing (which will involve estimation of leaked and unaccounted water, as also equity in distribution) needs to be institutionalised. Benchmarking is also necessary using common norms, for comparing the services amongst cities, and improvements over time.
- Rainwater harvesting and recycling of wastewater can meet the shortage of raw water experienced in the metropolitan cities to some extent.
- While there is a need to enhance water-cess, there is also a need to equitably distribute the revenue between the water supply & sanitation services. A combined collection of both water and sanitation-cess is necessary.
- The appropriateness of current norms of water supply for rural sector needs to be studied. In the long term, reducing the urban-rural gap is necessary.
- Much thinking about suitable models and procedures for privatisation is necessary.
- Rural areas, particularly those with chronic ground water quality problems, need to be covered under piped surface water supplies.

Availability of water is not uniform in all parts of India. There are acute shortages of sustainable water sources in many States and this requires transfer of water within the river basin or from other basins. With rapid urbanization, traditional sources of water for urban centres are getting exhausted and are getting polluted, necessitating tapping of distant sources, which are expensive to develop and convey. In many metropolitan and mega cities, augmentation of water supply has been done or being planned from distant sources, per force, at huge cost viz., Delhi, Bangalore, Chennai, Hyderabad, Ahmedabad, Mumbai, Indore and many urban towns in Saurashtra and Kutch from Narmada Canal involving long conveyance system and pumping. Solving the domestic water supply problems could be a driving force for inter-basin water transfer.

**Industrial Water Supplies**

The Water Policy, while allowing some flexibility, gives a relatively lower priority to the industrial water use as compared to agricultural water use. This may not always be appropriate, particularly in the regime of food self sufficiency, provided, locally, irrigation is not linked with poverty alleviation. In many areas, industrial water supply priorities may have to be raised.

While the industrial effluent discharges need to be closely monitored and the industries regulated strictly, a transient regime of incentives is necessary to enable the small scale industry, in particular, to stay viable, in place and to improve the treatment facilities.

**Estimating Water Use and Requirement of ‘Nature’ Sector**

(a) Forestland requirements:

The nature sector requirements include both, the ET needs of the natural land based ecosystems like the forests, savannas etc. as also the fresh water needs of the riverine, estuarial and coastal ecosystems, which require supply of freshwater for meeting their consumptive or habitat needs.

In the ‘natural’ state, larger land surface would have been covered by the forest / vegetation. But now, much land surface is used for purposes determined by human
interventions. The amount of land required to be kept in the natural state has been considered, in India to be about 15 percent. It is however not known as to i) why and how this percentage is determined. Is it a national target, or is it to be targeted separately in each political/administrative unit, basin etc? If the logic is based on the use of these natural areas as CO$_2$ sinks, these could be anywhere in the hemisphere in view of the global nature of the air circulation. If these are required for protecting the typical natural flora and fauna, it could be anywhere in the same climatic region. Ideally it should be promoted consistent with availability in time/ space/ quantity/ quality.

In any case, expanse of the natural forests must have shrunk in say last 200 years, because of population growth. Preventing a further reduction appears to be a policy option providing sustenance of present size of ecosystem. This approach has been adopted in the present studies.

(b) Environmental flow requirements of riverine ecosystem:

Similar dilemmas are apparent in regard to the riverine ecosystem needs. Brahmani river has a considerable lean season flow, and a good amount of fish life may be existing in lower reaches, although the water development structures like Jenapur dam of early 20th century and Rengali dam of late 20th century might have caused obstruction to their movement. They can’t be done away with. Considerable mangroves cover mouths of Brahmani and other rivers, which have a common delta. The mangrove around Bhitarkanika is well known. Migration of people from within and outside the basin and new settlements in the mangrove areas seem to be the main reason for the reduction of mangrove areas. The mangrove species prevalent in any area are likely to depend on the tidal range, the salinity levels in the estuary, and the salinity in the root zone soil moisture/ groundwater. Unfortunately, no relation between headwater discharge and estuarial salinity is available nor could be established from the available sparse data. It could form a basis for a separate study.

In absence of relevant study, an attempt was made to verify whether the fresh water input available to the estuarial/riverine ecosystem, in future, could be maintained for the basins like Brahmani at the current level; and for basins like Sabarmati, could be better than the present level. Although Sabarmati basin is water short, the possibility of large inter-basin transfer allows targeting a plan, which, apart from using more water for agriculture, allows restoration of the groundwater regime and possibly river flows for improvement of quality through reuse of effluents.

Avoiding pollution of natural waters

In India, adequate legal safeguards, about the quality of wastewater being discharged into natural waters, exist. If these could be properly implemented, little more would be required.

Apart from the all-pervading issue of good governance, there are many policy related issues, which call for implementation of the standards. To quote a few:

- If an industry is to strictly implement the standards, costs go up. Since most products have an all India market, action by one state can shift the business in favour of a state who is not so strict, and economic/ employment related problems would result. Implementation therefore has to be uniform in all states.
- Most municipalities and local-self-governments have hardly any financial sustainability or autonomy. Both investments on sewage treatment and recovery of cost appear very difficult. A national programme and budgeting on health enhancement is called for.
- Water prices for domestic freshwater supplies, apart from being inadequate, do not often have any element of sewage treatment.
- Privatisation of water supply and sewage treatment services could become more efficient but could involve enhanced tariff.
- Inadequate power supply for sewage treatment, lack of land availability for cheaper treatment alternatives like duckweed or oxidation ponds, and the impracticability of taking any punitive action against water supply and water treatment agencies, compound the problem of inadequate treatment of effluents.
- Non point source pollution from agricultural operations can be minimised if drainage schemes are implemented and pollutants reach an outfall through a common point, where treatment could be given.

The policy related issues could include:
- A dialogue between upstream and downstream users is necessary, to enable acceptable price increase.
Any plan for domestic or industrial use must include a plan for treatment and recycling.

The effluents standards, today, are uniform and do not distinguish between effluents being discharged in a small stream or a large river. A re-look is necessary. Best course is to disallow discharge of polluted waters into natural streams. Treated waters should be handed over to potential downstream users for recycling.

The National Water Policy (2002) already accepts the ‘user pays, polluter pays’ principle. This principle can be elaborated by having a tariff structure as follows:

- A user charge, per unit volume of water withdrawn by the user.
- A rebate, per unit volume of water duly treated by the user (for another purpose, for recycling or discharge to the natural system).
- A pollution charge, per ton of pollutant, at rates specified for each type of pollutant returned by the user to the natural system. This charge can also be in slabs, pollution up to the permissible standards being charged at the lowest rate, with increases in steps. Polluter should pay for a treatment plant, not for envisaged treatment.

The Desirability of Large and High Irrigation Lift

Surface water irrigation projects were all based on irrigating the ‘command’ area, at a level lower than the diversion point, though a ‘gravity’, distribution. This created a somewhat anomalous situation. People with lands a few meters above the reservoir or the canal did not benefit from the project, while lands at lower level, hundreds of kilometres away, did. Low lifts, using the electric or diesel energy now available throughout the country could benefit these areas in the vicinity of the head-works, thus easing some upstream downstream conflicts and perhaps also saving in capital cost through a more compact distribution system.

While such low lifts may be both economical and socially desirable, large lifts coupled with long conveyance systems would be very costly. A traditional major and medium scheme in India costs about Rs.100,000 per ha of gross irrigation. Thus, at 10% rate of interest, the annual supply of about 5000 m³ of irrigation water for a hectare would cost around Rs.10,000 or about Rs.2 per cubic meters, at the delivery point. A cubic meter of water lifted through 100 m has a potential energy of 0.27 KWH added to it. With a total (electrical, mechanical and hydraulic) efficiency of about 80 percent, the electrical energy used would be about 0.34 KWH, and at an economic price of Rs.5/KWH, the cost of the water would have an added energy component of Rs.1.70 per cubic meters.

If a scheme involves storage, long distribution and lift of say 200m, the annual cost irrigating one hectare with a delta of 0.5 m would have an annual cost of Rs.10000 of gravity civil works and Rs.17,000 for energy, and say, Rs.2000 for pump-house annual cost. Using this water for traditional crops, which may create a value addition of only say Rs.2000 per ha appears to be wrong economically.

Today many southern states are planning high lifts of their rightful waters, for use in high level plateau lands for irrigation. The Godavari lift irrigation of Andhra Pradesh, the ‘Krishna-Marathwadi’ or the ‘west flowing rivers to Godavari’ lifts planned by Maharashtra, the lifts from Narmada canal to fill up reservoirs in Sabarmati basin etc are examples of such schemes. Whatever be the political – social desirability of these, their economic viability needs to be critically examined.

The water policy needs to favour low lifts for irrigation, but needs to discourage high-energy intensive lifts for irrigation. Exercising water rights by the states has to be constrained by pragmatic economic sense. An economical interstate use would have to be preferred over a prima facie uneconomic intrastate use.

Wherever, polluting industries tend to follow the zero effluent norms, what is intended is to abstract only the make-up water, recycling the rest. It sometimes could pollute ground water. Also, in water deficit areas, such norms, based on somewhat non-beneficial ET within the industrial premises, may lead to larger depletion of water resources. In many such cases, insistence of return of treated effluent could be preferable to zero effluent.

Other Specific Interventions in National Water Policy

The foregoing indicates some of the interventions thrown up through the studies and analyses conducted so far, for CPSP. The specific to NWP issues were highlighted in Annexure 3. The following aspects were discussed in the Indian National Consultation held in November 2003.

- Undertake and complete several studies recommended in the NCWRDP report. Identify a time bound programme for investments needed in the Five Year Plans to match with needs of 2025.
Reconcile differences of views among NCIWRDP, MOWR, CWC, CGWB on priority. Integrate surface water and groundwater. Aim for attaining equity, efficiency, economy and efficacy in all aspects of Water Resources Development.

Identify basin wise contemplated storage schemes and undertake and complete them by 2025. Enhance simultaneously useable waters through special means such as Inter-basin Transfers.

Undertake water shed development and management in rain-fed areas through ample provisions made by MOA, MOEF and MORD.

Maintain food security through sufficiency plus buffer stocks and governance for 2025. Divert areas to cash crops if and when food production exceeds this threshold level.

Collect, evacuate, treat and recycle all wastewater. Don’t allow release of polluted water directly rivers. Industry should only avail make-up water. Implement drainage schemes for irrigated agriculture to convert non-point sources of pollution to point sources of collected drainage water to enable treatment and reuse.


Assess lengths of river systems presently supporting aquatic eco-systems. Try to sustain them. Assess goods and services provided by eco-systems for humans. Where possible, shift fishery to reservoirs from flow systems.

Stop encroachments of mangroves, assess freshwater need and provide it by pipelines, rather than through EFRs. Dispassionately examine EFRs and MFNs needs. They are expensive and do not reach the targets if needs of en-route human systems are unattended. Provide them from MAR left after meeting human needs.

Estimate and project for public awareness, flood amelioration provided by dams, including drought proofing and avoided desertification.

Adopt all science and technological interventions on priority to cause realization of the objects of IWRDM.
ANNEXURES

ANNEXURE 1
SOME COMMON ISSUES RELATED TO WATER SUPPLY AND SANITATION (UWSS) IN INDIAN CITIES

Management of urban water supply and sewerage services

The general financial position of many urban water supply and sewerage institutions are poor and so also their management. Only few Urban Local Bodies (ULB) / Boards in large urban areas generate sufficient revenues to make any contribution to investment in the sector – small and medium towns do not collect sufficient revenues to cover even the operating expenses of urban water supply system. Low tariff results in direct subsidy to the users. Lot of pressure is building up on the urban infrastructure, due to growth of urban population. Lack of resources is one of the major causes for poor standards of services and maintenance and inability to expand the system to cater to additional demand. ULBs and Boards dealing with water supply and sanitation services have very little autonomy in personnel and financial matters. Information systems necessary for effective management are mostly lacking.

With rapid urbanization, traditional sources of water for urban centers are getting exhausted and are getting polluted, necessitating to reach distant sources which are expensive to develop and convey. In many metropolitan and mega cities augmentation of water supply have been done or being planned form distant sources, per force, at huge cost viz. Delhi, Bangalore, Chennai, Hyderabad, Ahmedabad, Mumbai, Indore and many urban towns in Saurashtra and Kutch from Narmada canal involving long conveyance system and pumping & storage. Long distance transfer of water would also need to include component of requirement of water supply in future.

Leakage and unaccounted for water

While the urban water supply systems are generally designed for a per capita supply of 150 liters per day plus assumed allowance of 15% for loss in the distribution system, in practice actual per capita supply reaching the consumer is much less due to leakages in the distribution network and losses due to other unauthorized use. As per a survey conducted by National Environmental Engineering Research Institute (NEERI), the total system losses in most cities are much higher and range between 25 to 50%. Water supply is generally intermittent and available for 2 – 8 hours a day, in most of the cities. Besides, leakage leads to low pressure in the system, and intermittent supply leads to back siphoning resulting in contamination in the distribution network, in many cities.

Deficient per capita supply

There are also many metropolitan and mega cities where the per capita supply itself is lower than the design norms due to scarcity of source viz. Bangalore 107 lpcd, Hyderabad 114 lpcd, Chennai 100 lpcd.

Water auditing systems

These have not been institutionalised. The recent initiatives by the Brihan Mumbai Corporation to use high technology for instrumentation and water auditing are a step in the right direction.
Conservation, augmentation and recycling of urban water

Water is precious and its use must be optimised. There has been no thrust on conserving water either in the mega cities or in small towns. There is lot of wastage of water due to leakage, and due to old rusted pipes and poor maintenance of the system and from free PWH. These must be controlled and brought to a minimum level.

Large quantities of potable water are used for non-potable use even when there is acute scarcity of water. Water for flushing toilets, industrial cooling, watering gardens and parks, washing cars can all be done by non-potable water, which may be available from local sources. Sewage effluent after tertiary treatment could be used for the above purposes. For example in Dwarka, a vast colony in South West Delhi is facing acute shortage of water. The ground water in that locality is brackish and unfit for drinking purposes. Part of the waste water of the colony can be given suitable treatment and used for flushing the toilets, and for gardening, there by saving potable water and reducing the quantum of waste water going to the river.

Sewage effluent after suitable treatment can be used for industrial water requirement, in urban areas. A few industries in Bombay and Chennai have started using urban wastewater, after suitable treatment in the industry resulting in conservation of fresh water.

In the tenth plan, several financial incentive measures have been proposed to promote reforms in UWSS sector such as city challenge and Pooled Finance Development Fund to encourage ULBs to become viable and to access market funds. Tenth Five Year Plan proposes Urban Reforms Incentive Funds to encourage ULBs to take up financial reforms and strengthening. The Plan also proposes diagnostic study of operational status of existing investments and review of practices in management and finances in the UWSS sector.

The Tenth Five Year Plan proposes continuation of Central Grant to Small Towns Under Accelerated Urban Water Supply Programme and has included sanitation also under the package so that the same is taken up as a comprehensive package.

Privatization of services

Several options are available for privatisations. UWSS organizations could be totally privatised as was done in UK, some years back. A management contract may be awarded solely for operating a facility for water supply or other utility or a lease contract for a finite period may be awarded in return for sharing the revenue from water charges or a concession contract may be awarded for a longer period say 25 to 30 years for a fee for operation and maintenance of the services. A build-operate-transfer contract may be awarded for a fixed term to attract investment, in anticipation of profit.

Involving private partnership in water sector will assist in the availability of additional finances, and better input of technical and management skills. Public private partnership is an effective means of establishing co-operation between public and private sectors, and to bundle financial resources and technical expertise to address urban water needs.

A beginning has already been made in the above respect by some of the urban water supply utilities in the country viz Chennai, Bangalore, and Delhi etc. However, if the modalities of privatisation including the interfacing of these proposals with the protection of water rights of the upstream and downstream users are not well worked out, the proposals attract severe criticism about sell out of natural waters. Much thinking and procedural standardization is necessary.

Rural water supply and sanitation

In order to address the problem of sustainability in Rural Water Supply and Sanitation, the GOI approved sector reforms programme in March 1999 to ensure active participation of the community. State Governments have identified 63 pilot districts for introducing the reforms. The implementation of reforms project has already commenced. The experience gained during the implementation of the pilot projects will be utilized for expanding the reform package to other districts, in the second phase.
The status and issues related to D&I sector were studied through a study of ten cities/urban conglomerates and one industrial conglomerate (i.e. Angul Talcher). Data on various facets of water supply and sanitation systems in ten cities as received from concerned local bodies are summarized in Table A2-1. Guess-estimates have been made wherever necessary, in particular for future projections.

Water supply systems are normally designed for a period of 30 years. Good quality of material and good workmanship has prolonged the life of various components in particular the pipes, for much longer period than designed. Table A2-2 indicates years when the piped water supply system was first laid in some of the cities and the change in capacity that has occurred since the last re-organisation of the system.

Problems in operation and maintenance have multiplied with age. Often, proper repairs are hindered by traffic and congestion in the city and pressing demand for restoration of supply after a shutdown for repairs.

Present (2000) supply and demand

Table A2-3 depicts the present demand and supply, indicating the gap in service as also the level of service in terms of water supplied per capita per day.

With the exception of Surat, reorganisation and augmentation of water supply system has lagged behind demand in the other cities. As a result, there is scarcity of water in practically every urban local body. Scarcity is exacerbated by uneven distribution of water. Thus while the quantity of water supplied per capita per day presents a happy picture in Delhi, the misery in even some of the posh colonies of New Delhi appear to be the result of deficiencies in the management of distribution system.

Future demand of water

Information for future demand is not uniformly available. It is either related to a Master Plan, having its own time horizon or not stated at all. The figures show that demand in the next decade is likely to rise steeply in some cities like Surat and Delhi with annual rate of growth exceeding 7-10 percent.

In all urban local bodies, water is supplied by a combination of connections to individual premises and public stand-posts. In some cases, more as an exception than rule, water connections are metered. The data shows the number of metered connections to be the highest in Delhi.

Some specific information regarding supply, losses, tariff, quality, conservation and efforts at getting public cooperation are as under.

Metering of domestic connections

In Delhi, the number of un-metered connections increased particularly after the cholera episode in 1988 when it was decided to extend water connections in slum areas, unauthorised colonies and urbanised villages.

Pune had water meters on house connections. However, unending problems related to their malfunction and repairs, have forced the local body resort to levy water tax based on rateable value of property instead of measurement, thereby putting an end to water meters.

Cost and Tariff

Data on cost of water treatment and cost of water delivered are shown in the Table A2-4, along with the tariff for water supplied for domestic and commercial/industrial purposes. While the information is scanty and too varied to find any rationale in it, it is noteworthy that tariff is even lower than the cost of water in several cases. Also, cost of raw water is generally not taken into consideration.

Water losses

In most cases, hardly any information was available on loss of water in conveyance and distribution. Where it is available, it could hardly be relied on. For example, for Gandhinagar, it was stated that such losses were 1 to 2 per cent. It appears to be a case of wrong reporting. For Pune, a more credible figure of 20% is reported to be the losses in conveyance and distribution system.

The particulars related to Delhi may be illustrative on this subject. Since 1978, a leakage detection cell has done useful work in Delhi with the help of sophisticated instruments including leak noise co-relator, ground microphone, sounding rods, pipe and cable locators and metal detectors. Delhi Jal Board (DJB) study estimates that the leakage in pipelines is limited and is in the range of 15 to 18 per cent of the flow. The quantity of unaccounted-for water is much higher, though not precisely known,
### Table A2-1

Present and Future (2025) Requirement of Urban Domestic Water Supply in Selected Cities

<table>
<thead>
<tr>
<th>S No</th>
<th>City</th>
<th>Population in 2001 (Million)</th>
<th>Present Supply (Mid) (lpcd)</th>
<th>Present Supply norms (1) (lpcd)</th>
<th>NCIWRDP NORMS (3) (lpcd)</th>
<th>Source of Water</th>
<th>Water supply Through pipeline %</th>
<th>Water leaks and unaccounted for water (UFW) (4) %</th>
<th>Stand pipe and tanker supply %</th>
<th>Average calculated Net supply 2001 (lpcd)</th>
<th>(Mm³/year) 2001</th>
<th>Average calculated Net supply 2025 (lpcd)</th>
<th>(Mm³/year) 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Sabarmati &amp; Adjoining Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Ahmedabad</td>
<td>3.65</td>
<td>505</td>
<td>138</td>
<td>150+15%</td>
<td>220</td>
<td>Reservoirs, Ranney wells, Tubewells</td>
<td>80</td>
<td>20</td>
<td>35</td>
<td>90</td>
<td>184</td>
<td>398</td>
</tr>
<tr>
<td>2</td>
<td>Gandhinagar</td>
<td>0.20</td>
<td>45</td>
<td>225</td>
<td>135+15%</td>
<td>220</td>
<td>-do-</td>
<td>90</td>
<td>10</td>
<td>35</td>
<td>146</td>
<td>16</td>
<td>58</td>
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<tr>
<td>3</td>
<td>Surat</td>
<td>2.55</td>
<td>510</td>
<td>200</td>
<td>150+15%</td>
<td>220</td>
<td>-do-</td>
<td>80</td>
<td>20</td>
<td>35</td>
<td>130</td>
<td>186</td>
<td>278</td>
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<tr>
<td>4</td>
<td>Baroda</td>
<td>1.5</td>
<td>221</td>
<td>147</td>
<td>150+15%</td>
<td>220</td>
<td>-do-</td>
<td>80</td>
<td>20</td>
<td>35</td>
<td>95</td>
<td>81</td>
<td>163</td>
</tr>
<tr>
<td>B.</td>
<td>Brahmani &amp; Adjoining Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>Bhubaneshwar</td>
<td>0.66</td>
<td>171</td>
<td>206</td>
<td>135+15%</td>
<td>220</td>
<td>River, Tubewells</td>
<td>60</td>
<td>40</td>
<td>35</td>
<td>134</td>
<td>62</td>
<td>123</td>
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<tr>
<td>6</td>
<td>Cuttak</td>
<td>0.51</td>
<td>108</td>
<td>209</td>
<td>135+15%</td>
<td>220</td>
<td>Tubewells</td>
<td>42</td>
<td>58</td>
<td>35</td>
<td>135</td>
<td>39</td>
<td>61</td>
</tr>
<tr>
<td>7</td>
<td>Puri</td>
<td>0.11</td>
<td>20</td>
<td>124</td>
<td>135+15%</td>
<td>220</td>
<td>Reservoir</td>
<td>30</td>
<td>70</td>
<td>35</td>
<td>80</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>C.</td>
<td>Sample Mega &amp; Metro Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Delhi</td>
<td>13.8</td>
<td>3000</td>
<td>274</td>
<td>150+15%</td>
<td>220</td>
<td>River, Reservoirs, Canal, Groundwater, Ranney Wells</td>
<td>80</td>
<td>20</td>
<td>40</td>
<td>164</td>
<td>1095</td>
<td>2422</td>
</tr>
<tr>
<td>9</td>
<td>Mumbai</td>
<td>11.82</td>
<td>2925</td>
<td>247</td>
<td>150+15%</td>
<td>220</td>
<td>Reservoir</td>
<td>80</td>
<td>20</td>
<td>30</td>
<td>159</td>
<td>1067</td>
<td>1430</td>
</tr>
<tr>
<td>10</td>
<td>Pune</td>
<td>3.0</td>
<td>1100</td>
<td>296</td>
<td>150+15%</td>
<td>220</td>
<td>Reservoir</td>
<td>80</td>
<td>20</td>
<td>35</td>
<td>238</td>
<td>325</td>
<td>995</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>37.81</td>
<td>8605</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3140</td>
<td>5941</td>
<td></td>
</tr>
</tbody>
</table>

(1) CPHEEO—Central Public Health Environmental and Engineering Organisation
(2) 15% - for losses in the distribution network
(3) NCIWRDP - National Commission on Integrated Water Resources Development Plan
(4) Estimated

India as per NCWRDP (for Urban Population)

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (urban)</th>
<th>Requirement of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>285 Million</td>
<td>15.72 BCM/Year</td>
</tr>
<tr>
<td>2025</td>
<td>632 Million</td>
<td>43.86 BCM/Year</td>
</tr>
</tbody>
</table>

- @ 170 lpcd for 65% urban population presumed to be living in Class I cities and 100 lpcd for other than Class I cities
- @ 220 lpcd for Class I cities and 150 lpcd for non-Class I cities
### Table A2-2. Piped Water Supply and Capacity in the Selected Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Year in which water supply system was</th>
<th>Initial supply capacity Million litres/day</th>
<th>Year in which the system was last reorganised</th>
<th>Present supply capacity Million litres/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhubaneswar</td>
<td>1954</td>
<td>7.00</td>
<td>1996</td>
<td>171</td>
</tr>
<tr>
<td>Cuttack</td>
<td>1949</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Not stated</td>
</tr>
<tr>
<td>Puri</td>
<td>1928</td>
<td>Not stated</td>
<td>2001</td>
<td>20</td>
</tr>
<tr>
<td>Delhi</td>
<td>1900</td>
<td>7.50</td>
<td>2003</td>
<td>3,000</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>1891</td>
<td>Not stated</td>
<td>2000</td>
<td>505</td>
</tr>
<tr>
<td>Gandhinagar</td>
<td>1967-68</td>
<td>22</td>
<td>1985</td>
<td>45</td>
</tr>
<tr>
<td>Surat</td>
<td>Prior to 1991</td>
<td>140</td>
<td>2003</td>
<td>510</td>
</tr>
<tr>
<td>Pune</td>
<td>1928</td>
<td>483</td>
<td>2000</td>
<td>1,100</td>
</tr>
</tbody>
</table>

### Table A2-3. Present Water Demand and Supply in Selected Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Present demand (Million litres/day)</th>
<th>Present supply (Million litres/day)</th>
<th>Population served Million</th>
<th>% of total</th>
<th>Per capita water supplied (Litres/capita/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhubaneswar</td>
<td>117</td>
<td>171</td>
<td>0.66</td>
<td>62%</td>
<td>203</td>
</tr>
<tr>
<td>Cuttack</td>
<td>Not stated</td>
<td>108</td>
<td>0.51</td>
<td>80%</td>
<td>209</td>
</tr>
<tr>
<td>Puri</td>
<td>22</td>
<td>20</td>
<td>0.11</td>
<td>71%</td>
<td>124</td>
</tr>
<tr>
<td>Delhi</td>
<td>3,700</td>
<td>3,000</td>
<td>13.8</td>
<td>86%</td>
<td>274</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>Not stated</td>
<td>505</td>
<td>3.65</td>
<td></td>
<td>138</td>
</tr>
<tr>
<td>Gandhinagar</td>
<td>64</td>
<td>45</td>
<td>0.20</td>
<td></td>
<td>225</td>
</tr>
<tr>
<td>Surat</td>
<td>Not stated</td>
<td>510</td>
<td>2.55</td>
<td>95%</td>
<td>200</td>
</tr>
<tr>
<td>Pune</td>
<td>1,100</td>
<td>1,100</td>
<td>3.00</td>
<td>100%</td>
<td>200</td>
</tr>
</tbody>
</table>

### Table A2-4. Water Tariff for Domestic and Commercial/Industrial Purposes

<table>
<thead>
<tr>
<th>City</th>
<th>Cost of water treatment (Rs. / Kl)</th>
<th>Cost of water supplied (Rs. / Kl)</th>
<th>Charges for domestic delivery</th>
<th>Charges for commercial/industrial supply (Rs. / Kl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhubaneswar</td>
<td>3.14</td>
<td>Not stated</td>
<td>Rs. 2.42/kl</td>
<td>5.64 / 4.83</td>
</tr>
<tr>
<td>Cuttack</td>
<td>Chlorination only for 0.07</td>
<td>Not stated</td>
<td>Rs. 55 per tap</td>
<td>3.50 / 3.00</td>
</tr>
<tr>
<td>Puri</td>
<td>Not stated</td>
<td>3.90</td>
<td>2.40</td>
<td>5.65 / 4.85</td>
</tr>
<tr>
<td>Delhi</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Rs. 0.525 to 4.50 / kl (more for higher consumption)</td>
<td>7.50 to 15.00 / 12.00 to 18.00</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>3.50</td>
<td>Not stated</td>
<td>15% to 25% of assessed value of property</td>
<td></td>
</tr>
<tr>
<td>Gandhinagar</td>
<td>3.50</td>
<td>4.50</td>
<td>Rs.288 to 1440 annually, based on size of plot</td>
<td>Not stated</td>
</tr>
<tr>
<td>Surat</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Not stated</td>
</tr>
<tr>
<td>Pune</td>
<td>3.50</td>
<td>Not stated</td>
<td>Pro-rata property tax</td>
<td>16.00 / 16.00</td>
</tr>
</tbody>
</table>
because water flows without measurement through nearly
10,000 free stand posts and through numerous water
connections that are un-metered or have defective water
meters. DJB assesses the unaccounted-for water to be of the
order of 40 per cent of total supply.

Mumbai Municipal Corporation initiated long time
back action to detect and control leakages in the water
supply system using sophisticated electronic devices and
did excellent work and extended the work to large areas of
the corporation.

Surat has opted for instrumentation to manage its water
supply distribution network. For this purpose, on-line flow
meters and supervisory control and data acquisition system
are proposed to be installed.

Water Quality Monitoring

While some effort, even if indifferent, is made at every
city to monitor water quality, the practice adopted at Surat
deserves to be emulated.

Water Conservation

Considerable quantity of wastewater generated during
washing of filters can be recycled at the water treatment
plants. In Delhi, it is planned to save as much as 186 Mld at
four water treatment works.

Water Harvesting

Delhi Jal Board has made a beginning in water harvesting
on 200 buildings. Because groundwater is severely depleted
in south and southwest Delhi, Central Ground Water
Authority (COWA) has already made it mandatory for
large buildings to install water-harvesting systems and
banned abstraction of groundwater in these areas. Other
cities like Chennai, Hyderabad, Bangalore etc. have also
initiated rainwater-harvesting programmes. In Pune, a
project for harvesting of rainwater is at planning stage.

Water Supply by Tankers

During periods of extreme scarcity, the local bodies resort
to supply of water by tankers. Delhi Jal Board deploys nearly
1,000 tankers for meeting shortage of water supply in
specific areas. The service is free of cost to the community
although it is widely accepted that people pay substantial
tips to the tanker operators in their desperation to get this
service. The need for supply of water by tankers is so acute
that a large number of privately owned tankers are put in
service illegally. They obtain water from dubious sources
and sell it at an exorbitant price of Rs 100 per kl. In Pune,
nearly 730 kl are supplied annually through tankers at a
cost of Rs. 70,000 per day, which is borne by the local
body.

The worst effect of scarcity of water is on the
temperament of the people. Harsh words, abuses, and
scuffles during distribution of water by tankers in short
supply areas are common.

Privatization of Services

Recently, the water complaint centres at two locations
were privatised in Delhi. This is an experiment to improve
efficiency in acting on public complaints and fair dealing
in redressing public grievances. It is also proposed to utilise
biogas produced at of various sewage treatment plants by
engaging private entrepreneurs on build and operate basis.
In Surat, operation and maintenance of two water treatment
plants has been entrusted to private management. In
Ahmedabad also, scope for privatisation is recognised in
the management of treatment plants and pumping stations
but it has yet to be put into practice.

“Bhidadi”

Government of Delhi has promoted a scheme, called
“Bhidadi” (which means partnership) to generate co-
operation and joint responsibility between people and the
government. Following are some examples of schemes
adopted by Delhi Jal Board. Mainly, the partnership
involves the Residents Welfare Associations (RWA) in
collecting payments, requisitioning water tankers, getting
leaks repaired by consumers & getting sewers maintained.
RWAs are also given incentives for water harvesting.

Sewerage Status in the Selected Cities/ Urban
Conglomerates

Almost without exception, sewerage facilities have
lagged over time behind water supply facilities. This has
been one of the major causes of insanitation in urban areas
and pollution of surface and ground waters. Where
sewerage has been provided, house connections have
lagged. In general, the installed sewage treatment capacity
is not adequate to treat the entire quantity of the sewage
generated in an urban area. Tables A2-5 and A2-6 shows
the position in the selected cities. Guess-estimates have
been made where necessary, in particular for future
projections.

Maintenance and rehabilitation

It is seen that sewer maintenance in most of the cities
leaves much to be desired. In Delhi, there are several areas
where sewer lines are choked and sewage overflows to open drains. In certain localities sewers have also settled and require rehabilitation and augmentation of capacities in many places. So also is the situation in many other cities.

**Cost of Sewage Treatment**

For the treatment of sewage, conventional primary and secondary units have been adopted. The mode of disposal is not indicated in most cases and there is no indication of the amount of revenue earned through the disposal of sewage effluent on land.

**Disposal of treated sewage**

Irrigation of crops by treated or untreated sewage is widely practiced in India. Often, this is done at high risk, especially to the workers on such farms. However, little data has been received for utilisation of sewage, before or after its treatment. It is noted that at Pune, crops are grown in a certain area by direct use of sewage for irrigation and such crops include sugarcane. This is indeed hazardous to public health since sugarcane can be consumed in raw state.
Table A2-5
Waste Water Generation – Collection, Treatment and Disposal in Selected Cities

<table>
<thead>
<tr>
<th>S. No.</th>
<th>City</th>
<th>Population in 2001 (million)</th>
<th>Waterwater generation (80% of water supply (mid))</th>
<th>Waste water collection (assumed as 70% of generation) (mid)</th>
<th>STP Capacity (mid)</th>
<th>Type of Treatment</th>
<th>Waste water treated (% of collection)</th>
<th>Waster water generation (in 2001 Mm³/year)</th>
<th>Waste water generation projection (in 2025** Mm³/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Sabarmati &amp; Adjoining Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ahmedabad</td>
<td>3.65</td>
<td>466</td>
<td>395</td>
<td>258</td>
<td>Primary and secondary</td>
<td>65</td>
<td>170</td>
<td>318</td>
</tr>
<tr>
<td>2</td>
<td>Gandhinagar</td>
<td>.2</td>
<td>34</td>
<td>20</td>
<td>20</td>
<td>Not mentioned</td>
<td>100</td>
<td>13</td>
<td>46</td>
</tr>
<tr>
<td>3</td>
<td>Surat</td>
<td>2.55</td>
<td>415</td>
<td>357</td>
<td>315</td>
<td>Primary and secondary</td>
<td>88</td>
<td>151</td>
<td>222</td>
</tr>
<tr>
<td>4</td>
<td>Baroda</td>
<td>1.5</td>
<td>176</td>
<td>150</td>
<td>108</td>
<td>Primary and secondary</td>
<td>72</td>
<td>64</td>
<td>131</td>
</tr>
<tr>
<td>B. Brahmani &amp; Adjoining Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bhubaneswar</td>
<td>.66</td>
<td>137</td>
<td>About 60 mld in drains</td>
<td>Not installed</td>
<td>Septic tank and soakpit and drains</td>
<td>50</td>
<td>50</td>
<td>98</td>
</tr>
<tr>
<td>6</td>
<td>Cuttak</td>
<td>.515</td>
<td>80</td>
<td>About 30 mld in drains</td>
<td>33 mld under installation</td>
<td>Septic tank, soakpit and drains, stabilization ponds under construction</td>
<td>50</td>
<td>29</td>
<td>49</td>
</tr>
<tr>
<td>7</td>
<td>Puri</td>
<td>.114</td>
<td>16</td>
<td>10</td>
<td>10</td>
<td>Septic tank and soakpit and drains</td>
<td>50</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>C. Sample Mega &amp; Metro Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Delhi</td>
<td>13.8</td>
<td>2400</td>
<td>1680</td>
<td>2330</td>
<td>Primary and secondary units</td>
<td>—</td>
<td>876</td>
<td>1937</td>
</tr>
<tr>
<td>9</td>
<td>Mumbai</td>
<td>11.82</td>
<td>2340</td>
<td>1638</td>
<td>—</td>
<td>Partially primary</td>
<td>30</td>
<td>853</td>
<td>1144</td>
</tr>
<tr>
<td>10</td>
<td>Pune</td>
<td>3</td>
<td>850</td>
<td>666</td>
<td>332</td>
<td>Primary and secondary units</td>
<td>50</td>
<td>321</td>
<td>796</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>37.81</td>
<td>6914</td>
<td>4916</td>
<td>3373</td>
<td></td>
<td></td>
<td>2533</td>
<td>4751</td>
</tr>
</tbody>
</table>

Table A2-6. Yearly Domestic Wastewater Generation and Treatment in Urban Areas MM³

<table>
<thead>
<tr>
<th>Year</th>
<th>Generation of Urban Domestic Waste Water</th>
<th>Treatment of Urban Domestic Wastewater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample Cities</td>
<td>Country</td>
</tr>
<tr>
<td>Present (2001)</td>
<td>2533</td>
<td>8358*</td>
</tr>
<tr>
<td>2025</td>
<td>4752</td>
<td>35090</td>
</tr>
</tbody>
</table>

*CPCB Annual Report 2001-2002
**2025 Projections based on NCIWRDP Report
ANNEXURE 3
NATIONAL WATER POLICY (APRIL 2002)
(Note: Highlighted articles in the NWP are mainly related with CPSP)

1.6 Planning and implementation of water resources projects involve a number of socio-economic aspects and issues such as environmental sustainability, appropriate resettlement and rehabilitation of project-affected people and livestock, public health concerns of water impoundment, dam safety etc. Common approaches and guidelines are necessary on these matters. Moreover, certain problems and weaknesses have affected a large number of water resources projects all over the country. There have been substantial time and cost overruns on projects. Problems of water logging and soil salinity have emerged in some irrigation commands, leading to the degradation of agricultural lands. Complex issues of equity and social justice in regard to water distribution are required to be addressed. The development and over-exploitation of groundwater resources in certain parts of the country have raised the concern and need for judicious and scientific resource management and conservation. All these concerns need to be addressed on the basis of common policies and strategies.

1.7 Growth process and the expansion of economic activities inevitably lead to increasing demands for water for diverse purposes such as domestic, industrial, agricultural, hydro-power, thermal-power, navigation, recreation, etc. So far, the major consumptive use of water has been for irrigation. While the gross irrigation potential is estimated to have increased from 19.5 million hectare at the time of independence to about 95 million hectare by the end of the Year 1999-2000, further development of a substantial order is necessary if the food and fiber needs of our growing population are to be met. The country’s population, which is over 1.027 billion at present (2001 AD) is expected to reach a level of around 1.390 billion by 2025 AD.

1.8 Production of food grains has increased from around 50 million tonnes in the fifties to about 208 million tonnes in the Year 1999-2000. This will have to be raised to around 350 million tonnes by the year 2025 AD. The drinking water needs of people and livestock have also to be met. Domestic and industrial water needs have largely been concentrated in or near major cities. However, the demand for further in rural areas is expected to increase sharply as the development programmes improve economic conditions of the rural masses. Demand for water for hydro
and thermal power generation and for other industrial uses is also increasing substantially. As a result, water, which is already a scarce resource, will become even scarcer in future. This underscores the need for the utmost efficiency in water utilisation and a public awareness of the importance of its conservation.

1.9 Another important aspect is water quality. Improvements in existing strategies, innovation of new techniques resting on a strong science and technology base are needed to eliminate the pollution of surface and ground water resources, to improve water quality. Science and technology and training have to play important roles in water resources development and management in general.

1.10 National Water Policy was originally adopted in September, 1987. Since then, a number of issues and challenges have emerged in the development and management of the water resources. Therefore, the National Water Policy (1987) has been reviewed and updated.

Information System

2.1 A well developed information system, for water related data in its entirety, at the national / state level, is a prime requisite for resource planning. A standardised national information system should be established with a network of data banks and data bases, integrating and strengthening the existing Central and State level agencies and improving the quality of data and the processing capabilities.

2.2 Standards for coding, classification, processing of data and methods / procedures for its collection should be adopted. Advances in information technology must be introduced to create a modern information system promoting free exchange of data among various agencies. Special efforts should be made to develop and continuously upgrade technological capability to collect, process and disseminate reliable data in the desired time frame.

2.3 Apart from the data regarding water availability and actual water use, the system should also include comprehensive and reliable projections of future demands of water for diverse purposes.

Water Resources Planning

3.1 Water resources available to the country should be brought within the category of utilizable resources to the maximum possible extent.

3.2 Non-conventional methods for utilisation of water such as through inter-basin transfers, artificial recharge of ground water and desalination of brackish or sea water as well as traditional water conservation practices like rainwater harvesting, including roof-top rainwater harvesting, need to be practiced to further increase the utilisable water resources. Promotion of frontier research and development, in a focused manner, for these techniques is necessary.

3.3 Water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations. All individual developmental projects and proposals should be formulated and considered within the framework of such an overall plan keeping in view the existing agreements / awards for a basin or a sub-basin so that the best possible combination of options can be selected and sustained.

3.4 Watershed management through extensive soil conservation, catchment-area treatment, preservation of forests and increasing the forest cover and the construction of check-dams should be promoted. Efforts shall be to conserve the water in the catchment.

3.5 Water should be made available to water short areas by transfer from other areas including transfers from one river basin to another, based on a national perspective, after taking into account the requirements of the areas / basins.

Institutional Mechanism

4.1 With a view to give effect to the planning, development and management of the water resources on a hydrological unit basis, along with a multi-sectoral, multi-disciplinary and participatory approach as well as integrating quality, quantity and the environmental aspects, the existing institutions at various levels under the water resources sector will have to be appropriately reoriented / reorganised and even additional units created, wherever necessary. As maintenance of water resource schemes is under non-plan budget, it is generally being neglected. The institutional arrangements should be such that this vital aspect is given importance equal or even more than that of new constructions.

4.2 Appropriate river basin organisations should be established for the planned development and management of a river basin as a whole or sub-basins, wherever necessary.
Special multi-disciplinary units should be set up to prepare comprehensive plans taking into account not only the needs of irrigation but also harmonising various other water uses, so that the available water resources are determined and put to optimum use having regard to existing agreements or awards of Tribunals under the relevant laws. The scope and powers of the river basin organisations shall be decided by the basin states themselves.

**Water Allocation Priorities**

5 In the planning and operation of water resources systems, water allocation priorities should be broadly as follows:

- Drinking water
- Irrigation
- Hydro-power
- Ecology
- Agro-industries and non-agricultural industries
- Navigation and other uses.

However, the priorities could be modified or added if warranted by the area / region specific considerations.

**Project Planning**

6.1 Water resource development projects should, as far as possible be planned and developed as multipurpose projects. Provision for drinking water should be a primary consideration.

6.2 The study of the likely impact of a project during construction and later on human lives, settlements, occupations, socio-economic, environment and other aspects shall form an essential component of project planning.

6.3 In the planning, implementation and operation of a project, the preservation of the quality of environment and the ecological balance should be a primary consideration. The adverse impact on the environment, if any, should be minimised and should be offset by adequate compensatory measures. The project should, nevertheless, be sustainable.

6.4 There should be an integrated and multi-disciplinary approach to the planning, formulation, clearance and implementation of projects, including catchment area treatment and management, environmental and ecological aspects, the rehabilitation of affected people and command area development. The planning of projects in hilly areas should take into account the need to provide assured drinking water, possibilities of hydro-power development and the proper approach to irrigation in such areas, in the context of physical features and constraints of the basin such as steep slopes, rapid run-off and the incidence of soil erosion. The economic evaluation of projects in such areas should also take these factors into account.

6.5 Special efforts should be made to investigate and formulate projects either in, or for the benefit of, areas inhabited by tribal or other specially disadvantaged groups such as socially weak, scheduled castes and scheduled tribes. In other areas also, project planning should pay special attention to the needs of scheduled castes and scheduled tribes and other weaker sections of the society. The economic evaluation of projects benefiting such disadvantaged sections should also take these factors into account.

6.6 The drainage system should form an integral part of any irrigation project right from the planning stage.

6.7 Time and cost overruns and deficient realisation of benefits characterising most water related projects should be overcome by upgrading the quality of project preparation and management. The inadequate funding of projects should be obviated by an optimal allocation of resources on the basis of prioritisation, having regard to the early completion of on-going projects as well as the need to reduce regional imbalances.

6.8 The involvement and participation of beneficiaries and other stakeholders should be encouraged right from the project planning stage itself.

**Ground Water Development**

7.1 There should be a periodical reassessment of the ground water potential on a scientific basis, taking into consideration the quality of the water available and economic viability of its extraction.

7.2 Exploitation of ground water resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. The detrimental environmental consequences of over-exploitation of ground water need to be effectively prevented by the Central and State Governments. Ground water recharge projects should be developed and implemented for improving both the quality and availability of ground water resource.
7.3 Integrated and coordinated development of surface water and ground water resources and their conjunctive use should be envisaged right from the project planning stage and should form an integral part of the project implementation.

7.4 Over exploitation of ground water should be avoided especially near the coast to prevent ingress of seawater into sweet water aquifers.

Drinking Water

8. Adequate safe drinking water facilities should be provided to the entire population both in urban and in rural areas. Irrigation and multipurpose projects should invariably include a drinking water component, wherever there is no alternative source of drinking water. Drinking water needs of human beings and animals should be the first charge on any available water.

Irrigation

9.1 Irrigation planning either in an individual project or in a basin as a whole, should take into account the irrigability of land, cost-effective irrigation options possible from all available sources of water and appropriate irrigation techniques for optimising water use efficiency. Irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximise production.

9.2 There should be a close integration of water-use and land-use policies.

9.3 Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between head-reach and tail end farms and between large and small farms should be obviated by adoption of a rotational water distribution system and supply of water on a volumetric basis subject to certain ceilings and rational pricing.

9.4 Concerted efforts should be made to ensure that the irrigation potential created is fully utilised. For this purpose, the command area development approach should be adopted in all irrigation projects.

9.5 Irrigation being the largest consumer of fresh water, the aim should be to get optimal productivity per unit of water. Scientific water management, farm practices and sprinkler and drip system of irrigation should be adopted wherever feasible.

9.6 Reclamation of water logged / saline affected land by scientific and cost-effective methods should form a part of command area development programme.

Resettlement and Rehabilitation

10. Optimal use of water resources necessitates construction of storages and the consequent resettlement and rehabilitation of population. A national policy in this regard needs to be formulated so that the project-affected persons share the benefits through proper rehabilitation. States should accordingly evolve their own detailed resettlement and rehabilitation policies for the sector, taking into account the local conditions. Careful planning is necessary to ensure that the construction and rehabilitation activities proceed simultaneously and smoothly.

Financial and Physical Sustainability

11. Besides creating additional water resources facilities for various uses, adequate emphasis needs to be given to the physical and financial sustainability of existing facilities. There is, therefore, a need to ensure that the water charges for various uses should be fixed in such a way that they cover at least the operation and maintenance charges of providing the service initially and a part of the capital costs subsequently. These rates should be linked directly to the quality of service provided. The subsidy on water rates to the disadvantaged and poorer sections of the society should be well targeted and transparent.

Participatory Approach to Water Resources Management

12. Management of the water resources for diverse uses should incorporate a participatory approach; by involving not only the various governmental agencies but also the users and other stakeholders, in an effective and decisive manner, in various aspects of planning, design, development and management of the water resources schemes. Necessary legal and institutional provisions should be made at various levels for the purpose, duly ensuring appropriate role for women. Water Users’ Associations and the local bodies such as municipalities and gram panchayats’ should particularly be involved in the operation, maintenance and management of water infrastructures / facilities at appropriate levels progressively, and collection of water charges with a view to eventually transfer the management of such facilities to the user groups / local bodies.

*Gram Panchayats are local, village level elected bodies
Private Sector Participation

13. Private sector participation should be encouraged in planning, development and management of water resources projects for diverse uses, wherever feasible. Private sector participation may help in introducing innovative ideas, generating financial resources and introducing corporate management and improving service efficiency and accountability to users. Depending upon the specific situations, various combinations of private sector participation, in building, owning, operating, leasing and transferring of water resources facilities, may be considered.

Water Quality

14.1 Both surface water and ground water should be regularly monitored for quality. A phased programme should be undertaken for improvements in water quality.

14.2 Effluents should be treated to acceptable levels and standards before discharging them into natural streams.

14.3 Minimum flow should be ensured in the perennial streams for maintaining ecology and social considerations.

14.4 Principle of ‘polluter pays’ should be followed in management of polluted water.

14.5 Necessary legislation is to be made for preservation of existing water bodies by preventing encroachment and deterioration of water quality.

Water Zoning

15. Economic development and activities including agricultural, industrial and urban development should be planned with due regard to the constraints imposed by the configuration of water availability. There should be a water zoning of the country and the economic activities should be guided and regulated in accordance with such zoning.

Conservation of Water

16.1 Efficiency of utilisation in all the diverse uses of water should be optimised and an awareness of water as a scarce resource should be fostered. Conservation consciousness should be promoted through education, regulation, incentives and disincentives.

16.2 The resources should be conserved and the availability augmented by maximising retention, eliminating pollution and minimising losses. For this, measures like selective linings in the conveyance system, modernisation and rehabilitation of existing systems including tanks, recycling and re-use of treated effluents and adoption of traditional techniques like mulching or pitcher irrigation and new techniques like drip and sprinkler may be promoted, wherever feasible.

Flood Control and Management

17.1 There should be a master plan for flood control and management for each flood prone basin.

17.2 Adequate flood-cushion should be provided in water storage projects, wherever feasible, to facilitate better flood management. In highly flood prone areas, flood control should be given overriding consideration in reservoir regulation policy even at the cost of sacrificing some irrigation or power benefits.

17.3 While physical flood protection works like embankments and dykes will continue to be necessary, increased emphasis should be laid on non-structural measures such as flood forecasting and warning, flood plain zoning and flood proofing for the minimisation of damages and to reduce the recurring expenditure on flood relief.

17.4 There should be strict regulation of settlements and economic activity in the flood plain zones along with flood proofing, to minimise the loss of life and property on account of floods.

17.5 The flood forecasting activities should be modernised, value added and extended to other uncovered areas. Inflow forecasting to reservoirs should be instituted for their effective regulation.

Land Erosion by Sea or River

18.1 The erosion of land, whether by the sea in coastal areas or by river waters inland, should be minimised by suitable cost-effective measures. The States and Union Territories should also undertake all requisite steps to ensure that indiscriminate occupation and exploitation of coastal strips of land are discouraged and that the location of economic activities in areas adjacent to the sea is regulated.

18.2 Each coastal State should prepare a comprehensive coastal land management plan, keeping in view the environmental and ecological impacts, and regulate the developmental activities accordingly.

Drought-prone Area Development

19.1 Drought-prone areas should be made less vulnerable to drought-associated problems through soil-
moisture conservation measures, water harvesting practices, minimisation of evaporation losses, development of the ground water potential including recharging and the transfer of surface water from surplus areas where feasible and appropriate. Pastures, forestry or other modes of development which are relatively less water demanding should be encouraged. In planning water resource development projects, the needs of drought-prone areas should be given priority.

19.2 Relief works undertaken for providing employment to drought-stricken population should preferably be for drought proofing.

Monitoring of Projects

20.1 A close monitoring of projects to identify bottlenecks and to adopt timely measures to obviate time and cost overrun should form part of project planning and execution.

20.2 There should be a system to monitor and evaluate the performance and socio-economic impact of the project.

Water Sharing / Distribution amongst the States

21.1 The water sharing / distribution amongst the states should be guided by a national perspective with due regard to water resources availability and needs within the river basin. Necessary guidelines, including for water short states even outside the basin, need to be evolved for facilitating future agreements amongst the basin states.

21.2 The Inter-State Water Disputes Act of 1956 may be suitably reviewed and amended for timely adjudication of water disputes referred to the Tribunal.

Performance Improvement

22. There is an urgent need of paradigm shift in the emphasis in the management of water resources sector. From the present emphasis on the creation and expansion of water resources infrastructures for diverse uses, there is now a need to give greater emphasis on the improvement of the performance of the existing water resources facilities. Therefore, allocation of funds under the water resources sector should be re-prioritised to ensure that the needs for development as well as operation and maintenance of the facilities are met.

Maintenance and Modernisation

23.1 Structures and systems created through massive investments should be properly maintained in good health. Appropriate annual provisions should be made for this purpose in the budgets.

23.2 There should be a regular monitoring of structures and systems and necessary rehabilitation and modernisation programmes should be undertaken.

23.3 Formation of Water Users’ Association with authority and responsibility should be encouraged to facilitate the management including maintenance of irrigation system in a time bound manner.

Safety of Structures

24. There should be proper organisational arrangements at the national and state levels for ensuring the safety of storage dams and other water-related structures consisting of specialists in investigation, design, construction, hydrology, geology, etc. A dam safety legislation may be enacted to ensure proper inspection, maintenance and surveillance of existing dams and also to ensure proper planning, investigation, design and construction for safety of new dams. The Guidelines on the subject should be periodically updated and reformulated. There should be a system of continuous surveillance and regular visits by experts.

Science and Technology

25. For effective and economical management of our water resources, the frontiers of knowledge need to be pushed forward in several directions by intensifying research efforts in various areas, including the following:

- hydrometeorology;
- snow and lake hydrology;
- surface and ground water hydrology;
- river morphology and hydraulics;
- assessment of water resources;
- water harvesting and ground water recharge;
- water quality;
- water conservation;
- evaporation and seepage losses;
- recycling and re-use;
- better water management practices and improvements in operational technology;
- crops and cropping systems;
- soils and material research;
- new construction materials and technology (with particular reference to roller compaction
• concrete, fiber reinforced concrete, new methodologies in privatisation technologies,
• instrumentation, advanced numerical analysis in structures and back analysis);
• seismology and seismic design of structures;
• the safety and longevity of water-related structures;
• economical designs for water resource projects;
• risk analysis and disaster management;
• use of remote sensing techniques in planning development and management;
• use of static ground water resource as a crisis management measure;
• sedimentation of reservoirs;
• use of sea water resources;
• prevention of salinity ingress;
• prevention of water logging and soil salinity;
• reclamations of water logged and saline lands;
• environmental impact;
• regional equity.

Training

26. A perspective plan for standardised training should be an integral part of water resource development. It should cover training in information systems, sectoral planning, project planning and formulation, project management, operation of projects and their physical structures and systems and the management of the water distribution systems. The training should extend to all the categories of personnel involved in these activities as also the farmers.

Conclusion

27. In view of the vital importance of water for human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds, and considering its increasing scarcity, the planning and management of this resource and its optimal, economical and equitable use has become a matter of the utmost urgency. Concerns of the community needs to be taken into account for water resources development and management. The success of the National Water Policy will depend entirely on evolving and maintaining a national consensus and commitment to its underlying principles and objectives. To achieve the desired objectives, State Water Policies backed with an operational action plan shall be formulated in a time bound manner say in two years. National Water Policy may be revised periodically as and when need arises.
Agriculture is a way of life, a tradition, which, for centuries, has shaped the thought, the outlook, and the economic life of the people of India. Agriculture, therefore, is and will continue to be central to all strategies for planned socio-economic development of the country. Rapid growth of agriculture is essential not only to achieve self-reliance at national level but also for household food security and to bring about equity in distribution of income and wealth resulting in rapid reduction in poverty levels.

4. Over 200 million Indian farmers and farm workers have been the backbone of India’s agriculture. Despite having achieved national food security the well being of the farming community continues to be a matter of grave concern for the planners and policy makers in the country. The establishment of an agrarian economy which ensures food and nutrition to India’s billion people, raw materials for its expanding industrial base and surpluses for exports, and a fair and equitable rewards system for the farming community for the services they provide to the society, will be the mainstay of reforms in the agriculture sector.

5. The National Policy on Agriculture seeks to actualise the vast untapped growth potential of Indian Agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agro business, create employment in rural areas, secure a fair standard of living for the farmers and agricultural workers and their families, discourage migration to urban areas and face the challenges arising out of economic liberalization and globalisation. Over the next two decades, it aims to attain:

- A growth rate in excess of 4 per cent per annum in the agriculture sector
- Growth that is based on efficient use of resources and conservation of our soil, water and bio-diversity;
- Growth with equity, i.e., growth which is widespread across regions and farmers;
- Growth that is demand driven and caters to domestic markets and maximizes benefits from exports of agricultural products in the face of the challenges arising from economic liberalization and globalisation.

8. Rational utilization and conservation of the country’s abundant water resources will be promoted. Conjunctive use of surface and ground water will receive highest priority. Special attention will be focused on water quality and the problem of receding ground water levels in certain areas as a result of over-exploitation of aquifers. Proper on-farm management of water resources for the optimum use of irrigation potential will be promoted. Use of in situ moisture management techniques such as mulching and use of micro pressurised irrigation systems like drip and sprinkler and green house technology will be encouraged for greater water use efficiency and improving productivity, particularly of horticultural and vegetable crops. Emphasis will be placed on promotion of water harvesting structures and suitable water conveyance systems in the hilly and high rainfall areas for rectification of regional imbalances. Participatory community irrigation management will be encouraged.

13. Special efforts will be made to raise the productivity and production of crops to meet the increasing demand for food generated by unabated demographic pressures and raw materials for expanding agro-based industries. A regionally differentiated strategy will be pursued, taking into account the agronomic, climatic and environmental conditions to realize the full growth potential of every region. Special attention will be given to development of new crop varieties, particularly of food crops, with higher nutritional value through adoption of bio-technology particularly, genetic modification, while addressing biosafety concerns.

14. A major thrust will be given to development of rain-fed and irrigated horticulture, floriculture, roots and

*The Serial Numbers indicated are as per the Serial Number of the Agriculture Policy.
tubers, plantation crops, aromatic and medicinal plants, bee-keeping and sericulture, for augmenting food supply, exports and generating employment in the rural areas. Availability of hybrid seeds and disease-free planting materials of improved varieties, supported by network of regional nurseries, tissue culture laboratories, seed farms will be promoted to support systematic development of horticulture having emphasis on increased production, post harvest management, precision farming, bio-control of pests and quality regulation mechanism and exports.

48. The Government of India trust that this Statement of National Agriculture Policy will receive the fullest support of all sections of the people and lead to sustainable development of agriculture, create gainful employment on a self sustaining basis in rural areas, raise standards of living for the farming communities, preserve environment and serve as a vehicle for building a resurgent national economy.
5.2.1 Land Degradation:

The degradation of land, through soil erosion, alkali-salinization, water logging, pollution, and reduction in organic matter content has several proximate and underlying causes. The proximate causes include loss of forest and tree cover (leading to erosion by surface water run-off and winds), excessive use of irrigation (in many cases without proper drainage, leading to leaching of sodium and potassium salts), improper use of agricultural chemicals (leading to accumulation of toxic chemicals in the soil), diversion of animal wastes for domestic fuel (leading to reduction in soil nitrogen and organic matter), and disposal of industrial and domestic wastes on productive land. These in turn, are driven by implicit and explicit subsidies for water, power, fertilizer and pesticides, and absence of conducive policies and regulatory systems to enhance people’s incentives for afforestation and forest conservation. It is essential that the relevant fiscal, tariffs, and sectoral policies take explicit account of their unintentional impacts on land degradation, if the fundamental basis of livelihoods for the vast majority of our people is not to be irreparably damaged. In addition, to such policy review, the following specific initiatives would be taken:

a) Encourage adoption of science-based, and traditional sustainable land use practices through research and development of pilot scale demonstrations, and large scale dissemination, including farmer’s training, and where necessary, access to institutional finance.

b) Promote reclamation of wasteland and degraded forestland through formulation and adoption of multi-stakeholder partnerships involving the land owning agency, local communities, and investors.

c) Prepare and implement thematic action plans for arresting and reversing desertification.

5.2.2 Forests and Wildlife:

(i) Forests:

Forests provide a multiplicity of environmental services. Foremost among these is the recharging of mountain aquifers, which sustain our rivers. They also conserve the soil, and prevent floods and drought. They provide habitat for wildlife and the ecological conditions for maintenance and natural evolution of genetic diversity of flora and fauna. They are the traditional homes of forest dwelling tribes, the major part by far of whose livelihoods depend on forests. They yield timber, fuel-wood, and other forest produce, and possess immense potential for economic benefits, in particular for local communities, from sustainable eco-tourism.

On the other hand, in recent decades, there has been significant loss of forest cover although there are now tangible signs of reversal of this trend. The principal direct cause of forest loss has been the conversion of forests to agricultural lands, settlements, infrastructure, and industry. In addition, commercial extraction of fuel-wood, illegal felling, and grazing of cattle, has degraded forests. These causes, however, have their origins in the fact that the environmental values provided by forests are not realized as direct financial benefits by various parties, at least to the extent of exceeding the monetary incomes from alternative uses, including those arising from illegal use. Moreover, while forest dwelling tribes had generally recognized traditional community rights over the forests since antiquity, on account of which they had strong incentives to use the forests sustainably and to protect them from encroachers, following the commencement of formal forest laws and institutions in 1865, these rights were effectively extinguished in many parts of the country. Such disempowerment has led to the forests becoming open access in nature, leading to their gradual degradation in a classic manifestation of the “Tragedy of the Commons”, besides leading to perennial conflict between the tribals and the Forest Department, and constituting a major denial of justice.

It is possible that some site-specific non-forest activities may yield overall societal benefits significantly exceeding that from the environmental services provided by the particular tract of forest. However, large scale forest loss would lead to catastrophic, permanent change in the country’s ecology, leading to major stress on water resources and soil erosion, with consequent loss of agricultural productivity, industrial potential, living conditions, and the onset of natural disasters including drought and floods. In any event, the environmental values of converted forests must be restored, as nearly as may be feasible, to the same public.
The National Forest Policy, 1988, and the Indian Forest Act, as well as the regulations under it, provide a comprehensive basis for forest conservation. However, it is necessary, looking to some of the underlying causes of forest loss, to take some further steps. These include:

a) Give legal recognition of the traditional rights of forest dwelling tribes. This would remedy a serious historical injustice, secure their livelihoods, reduce possibilities of conflict with the Forest Departments, and provide long-term incentives to the tribals to conserve the forests.

b) Formulate an innovative strategy for increase of forest and tree cover from the present level of 23 percent of the country’s land area, to 33 per cent in 2012, through afforestation of degraded forest land, wastelands, and tree cover on private or revenue land. Key elements of the strategy would include:
   (i) the implementation of multi-stakeholder partnerships involving the Forest Department, local communities, and investors, with clearly defined obligations and entitlements for each partner, following good governance principles, to derive environmental, livelihood, and financial benefits;
   (ii) rationalization of restrictions on cultivation of forest species outside notified forests, to enable farmers to undertake social and farm forestry where their returns are more favourable than cropping, and
   (iii) universalization of the Joint Forestry Management (JFM) system throughout the country.

c) Focus public investments on enhancing the density of natural forests, mangroves conservation, and universalization of Joint Forestry Management,

d) Formulate an appropriate methodology for reckoning and restoring the environmental values of forests, which are unavoidably diverted to other uses.


5.2.4 Freshwater Resources

India’s freshwater resources comprise the single most important class of natural endowments enabling its economy and its human settlement patterns. The freshwater resources comprise the river systems, groundwater, and wetlands. Each of these has a unique role, and characteristic linkages to other environmental entities.

(i) River Systems

India’s river systems typically originate in its mountain eco-systems, and deliver the major part of their water resources to the populations in the plains. They are subject to siltation from sediment loads due to soil loss, itself linked to loss of forest and tree cover. They are also subject to significant net water withdrawals along their course, due to agricultural, industrial, and municipal use; as well as pollution from human and animal waste, agricultural runoffs, and industrial effluents. Although the rivers possess significant natural capacity to assimilate and render harmless many pollutants, the existing pollution inflows in most cases substantially exceed such natural capacities. This fact, together with progressive reductions in stream flows, ensures that the river water quality in the vast majority of cases declines as one goes downstream. The results include loss of habitat for many bird species, and loss of inland navigation potential. Apart from these, India’s rivers are inextricably linked with the history and religious beliefs of its peoples, and the degradation of important river systems accordingly offends their spiritual, aesthetic, and cultural sensibilities.

The broad direct causes of rivers degradation are, in turn, linked to several policies and regulatory regimes. These include tariff policies for irrigation systems and industrial use, which, through inadequate cost-recovery, provide incentives for overuse near the headwork’s of irrigation systems, and drying up of irrigation systems at the tail-ends. The result is excessive cultivation of water intensive crops near the headwork’s, which is otherwise inefficient, and causes waterlogging, and alkali-salinization of soil. The irrigation tariffs also do not yield resources for proper maintenance of irrigation systems, leading to loss in their potential. In particular, resources are generally not available for lining irrigation canals to prevent seepage losses. These factors result in reduced flows in the rivers.

Pollution loads are similarly linked to pricing policies leading to inefficient use of agricultural chemicals, and municipal and industrial water use. In particular, revenue yields for the latter two are insufficient to install and maintain sewage and effluent treatment plants, respectively. Pollution regulation for industries is typically not based on formal spatial planning to facilitate clustering of industries to realize scale economies in effluent treatment, resulting in relatively high costs of effluent treatment, and consequent increased incentives for non-compliance. There is, accordingly need to review the relevant pricing policy regimes and regulatory mechanisms in terms of their likely adverse environmental impacts.
The following comprise elements of an action plan for river systems:

a) Promote integrated approaches to management of river basins by the concerned river authorities, considering upstream and downstream inflows and withdrawals by season, pollution loads and natural regeneration capacities, to ensure maintenance of adequate flows and adherence to water quality standards throughout their course in all seasons.

b) Consider and mitigate the impacts on river flora and fauna, and the resulting change in the resource base for livelihoods, of multipurpose river valley projects, power plants, and industries.

c) Consider mandating the installation of water saving closets and taps in the building byelaws of urban centres.

(ii) Groundwater:

Groundwater is present in aquifers in many parts of the country. Unconfined aquifers (near the surface) are subject to annual recharge from precipitation, but the rate of recharge is impacted by human interference. Confined aquifers, on the other hand, occur below a substratum of hard rock. These aquifers generally contain pure water. The boundaries of groundwater aquifers do not generally correspond to the spatial jurisdiction of any local public authorities or private holdings, nor are they easily discernable, nor can withdrawals be easily monitored, leading to the unavoidable situation of groundwater being an open access resource.

The water table has been falling rapidly in many areas of the country in recent decades. This is largely due to withdrawal for agricultural, industrial, and urban use, in excess of annual recharge. In urban areas, apart from withdrawals for domestic and industrial use, construction works for housing and infrastructure such as roads, prevent sufficient recharge. In addition, some pollution of groundwater occurs due to leaching of stored hazardous waste and use of agricultural chemicals, like fertilisers and pesticides. Contamination of groundwater is also due to geogenic causes, such as leaching of arsenic from natural deposits. Since groundwater is frequently a source of drinking water, its pollution leads to serious health impacts.

The direct causes of groundwater depletion have their origin in the pricing policies for electricity and diesel. In the case of electricity, where individual metering is not practiced, a flat charge for electricity connections makes the marginal cost of electricity effectively zero. Subsidies for diesel also reduce the marginal cost of groundwater extraction to well below the efficient level. Given the fact that groundwater is an open access resource, the user then “rationally” (i.e. in terms of his individual perspective), extracts groundwater until the marginal value to him equals his low marginal cost of extraction. The result is inefficient withdrawals of groundwater by all users, leading to the situation of falling water tables. Support prices for several water intensive crops with implicit price subsidies aggravate this outcome by strengthening incentives to take up these crops rather than less water intensive ones.

Falling water tables have several perverse social impacts, apart from the likelihood of mining of deep aquifers, “the drinking water source of last resort”. The capital costs of pump sets and bore wells for groundwater extraction when water tables are very deep may be relatively high, with no assurance that water would actually be found. In such a situation, a user who may be a marginal farmer able to borrow the money only at usurious rates of interest, may, in case water is not found, find it impossible to repay his debts. This may lead to destitution, or worse. Even if the impacts were not so dire, there would be excessive use of electricity and diesel.

The efficient use of groundwater would, accordingly, require that the practice of non-metering of electric supply to farmers be discontinued in their own enlightened self-interest. It would also be essential to progressively ensure that the environmental impacts are taken into account in setting electricity tariffs, and diesel pricing.

Increased run-off of precipitation in urban areas due to impermeable structures and infrastructure prevents groundwater recharge. This is an additional cause of falling water tables in urban areas. In rural areas several cost-effective contour bunding techniques have been proven to enhance groundwater recharge. A number of effective traditional water management techniques to recharge groundwater have been discontinued by the local communities due to the onset of pump sets for groundwater extraction, and need to be revived. Finally, increase in tree cover, is also effective in enhancing groundwater recharge.

Pollution of groundwater from agricultural chemicals is also linked to their improper use, due to pricing policies, especially for chemical pesticides, as well as agronomic practices, which do not take the potential environmental impacts into account. While transiting through soil layers may considerably eliminate organic pollution loads in groundwater, this is not true of several chemical pesticides.
The following action points emerge:

a) Take explicit account of impacts on groundwater tables of electricity tariffs and pricing of diesel.

b) Promote efficient water use techniques, such as sprinkler or drip irrigation, among farmers. Provide necessary pricing, inputs, and extension support to feasible and remunerative alternative crops from efficient water use.

c) Support practices of contour bunding and revival of traditional methods for enhancing groundwater recharge.

d) Mandate rainwater harvesting in all new constructions in relevant urban areas, as well as design techniques for road surfaces and infrastructure to enhance groundwater recharge.

e) Support R&D in cost effective techniques suitable for rural drinking water projects for removal of arsenic and mainstream their adoption in rural drinking water schemes in relevant areas.

(iii) Wetlands:

Wetlands, natural and manmade, freshwater or brackish, provide numerous ecological services. They provide habitat to aquatic flora and fauna, as well as numerous species of birds, including migratory species. The density of birds, in particular, is an accurate indication of the ecological health of a particular wetland. Several wetlands have sufficiently unique ecological character as to merit international recognition as Ramsar Sites.

Wetlands also provide freshwater for agricultural and domestic use, help groundwater recharge, and provide livelihoods to fisher-folk. They may also comprise an important resource for sustainable tourism and recreation. They may be employed as an alternative to power, technology, and capital intensive municipal sewage plants; however, if used for this purpose without proper reckoning of their assimilative capacity, or for dumping of solid and hazardous waste, they may become severely polluted, leading to adverse health impacts. The inadvertent introduction of some alien species of flora in wetlands has also degraded their ecology.

Wetlands are under threat from drainage and conversion for agriculture and human settlements, besides pollution. This happens because public authorities or individuals having jurisdiction over wetlands derive little revenues from them, while the alternative use may result in windfall financial gains to them. However, in many cases, the economic values of wetlands' environmental services may significantly exceed the value from alternative use. On the other hand, the reduction in economic value of their environmental services due to pollution, as well as the health costs of the pollution itself, are not taken into account while using them as a waste dump. There also does not yet exist a formal system of wetland regulation outside the international commitments made in respect of Ramsar sites.

The following action points emerge:

a) Set up a legally enforceable regulatory mechanism for identified valuable wetlands to prevent their degradation and enhance their conservation. Develop a national inventory of such wetlands.

b) Formulate conservation and prudent use strategies for each significant catalogued wetland, with participation of local communities, and other relevant stakeholders.

c) Formulate and implement eco-tourism strategies for identified wetlands through multi-stakeholder partnerships involving public agencies, local communities, and investors.

d) Take explicit account of impacts on wetlands of significant development projects during the environmental appraisal of such projects; in particular, the reduction in economic value of wetland environmental services should be explicitly factored into cost-benefit analyses.

e) Consider particular unique wetlands as entities with "Incomparable Values", in developing strategies for their protection.

Water Pollution:

The direct and indirect causes of pollution of surface (river, wetlands) water sources, groundwater, and coastal areas have been discussed above. The following comprise further elements of an action plan:

a) Develop and implement, initially on a pilot scale, public-private partnership models for setting up and operating effluent and sewage treatment plants. Once the models are validated, progressively use public resources, including external assistance, to privatise such partnerships. Enhance the capacities of municipalities for recovery of user charges for water and sewage systems.
b) Enhance reuse of treated sewage and industrial wastewater before final discharge to water bodies.

c) Enhance capacities for spatial planning among the State and Local Governments, with adequate participation by local communities, to ensure clustering of polluting industries to facilitate setting up of common effluent treatment plants to be operated on cost recovery basis.

d) Promote R&D in development of low cost technologies for sewage treatment at different scales, in particular, replication of the East Kolkata wetlands model for sewage treatment to yield multiple benefits.

e) Take explicit account of groundwater pollution in pricing policies of agricultural inputs, especially pesticides, and dissemination of agronomy practices involving their use.

f) Develop a strategy for strengthening regulation, and addressing impacts, of ship-breaking activities on coastal and near marine resources.
Objectives

- To harness the untapped water wealth of the country.
- To add an additional irrigation potential of 20 million ha. In the next 15 years to meet the food and fiber requirements for a projected population of 1200 million by 2015 and 1600 by 2050 ensuring food security.
- To create an additional storages of 75 BCM. by 2015 and another 130 BCM. by 2050.
- To maximize the hydropower development.
- To make available safe drinking water for all near their households.
- To safeguard the existing water resources from pollution and over exploitation.
- To develop navigation in Inland water transport in the country.
- To reduce the gap between the irrigation potential created and utilized.
- To improve drainage for enhancing productivity.
- To ensure safety and serviceability of existing infrastructure and improve efficiency of irrigation water systems and its application.
- To engage in active ‘water diplomacy’ for mutually beneficial use of water resources of inter-national rivers shared with neighbouring countries for overall economic development in the region.
- To arrest land erosion along the riverbanks and the sea coasts.
- Optimizing the use of water as per agro-climatic conditions and drought proofing of arid areas.
- To help communities revive the traditional water storage techniques and structures for rain water harvesting.
- To bring benefits of water resources development to water scarce areas through inter-basin transfers.
- To improve ecology by maintaining minimum water flows in rivers.
- To arrest the advancement of deserts.
- Minimize the adverse environmental and social impact of water resources projects.
- Minimize mortality and morbidity due to water-related diseases.
- To mitigate miseries caused by water related natural disaster through flood and drought management.

Strategy

To achieve above objectives, following strategy has been designed.

- Integrated management of water resources development.
- Development of new resources.
- Optimal utilization of developed water resources.
- Preserving the resources.
- Realistic assessment of water resources and their requirements in different regions.
- Augmenting the available water resources by transferring water from surplus regions to water deficit areas.
- Stakeholders’ participation in water resources management.
- Demand side management through mass awareness.
- Optimal utilization of the flood plains keeping the adverse impacts to a minimum.
- Dissemination and application of technology and research.

Policy Focus

- Augmentation and development of additional resources
- Paradigm shift in emphasis towards improving the performance of existing infrastructure.
- Shift strategy towards efficient management of flood plains; flood proofing including disaster preparedness and response planning, flood forecasting and flood insurance.
Adopting a national resettlement and rehabilitation policy.

**Administrative Initiatives**
- Bringing all water related subjects under one umbrella.
- Setting up of River Basin Organisations for integrated management of water resources.
- Restructuring of Central Water Commission and Central Ground Water Board.
- Reorientation of Research Organizations.
- Bringing the National River Conservation Programme, Integrated Watershed Development Project and other related water subjects within the purview of the Ministry of Water Resources.

**New Legal Instruments**
- Development of National Water Code defining water rights, and developing Laws, Conventions and agreements on water pollution.
- Revision of the state Irrigation Acts to provide legal support to farmers’ participation.
- Legislation for development and regulation of ground water on a sustainable basis.
- Legislation to protect and prevent encroachment of all water bodies.
- Standing mechanism for settling water disputes.
- Legislation on dam safety.
- Creation of institutional arrangements with the requisite legal backing for integrated water management.

**Economic Instruments**
- Ensuring the financial sustainability/maintainability of the existing facilities.
- Evolving improved economic analysis procedures.
- Encouraging adoption of insurance as a flood management option.
- Linking central assistance to financial and institutional reforms.

**Investment and Financial Instruments**
- Ensuring adequate allocation of financial outlays for the water resources sector.
- Encouraging private sector participation in development and management of water resources.
- Setting up regulatory authority for rationalization of water rates.

**Social Change Initiatives**
- Stakeholders’ participation in planning of water resources.
- Users’ participation in development and management of water resources.
- Women’s participation in planning and management of water resources.
- Demand management by creating awareness.
- Increasing awareness towards water related ecological issues.

**Bridging the Knowledge Gap**
- Mass awareness on water preservation and conservation.
- Capacity building of users’ groups through NGOs and other professional organizations.
- Sponsoring and coordinating research in water sector.
The initiatives taken by the Ministry of Tribal Affairs, Govt. of India and the achievements made are as follows:

* * * * *

IV. Implementation of the provisions of National Common Minimum Programme

In order to operationalise provision of NCMP improvement in HDI of the ST population and creation of critical infrastructure in tribal areas, the Ministry during the year focused attention towards development of core sectors through its schemes which broadly relate to income generation, creation of infrastructure in critical areas, empowerment of the ST communities through education with special emphasis on girls, augmenting productivity of the natural resource-base, including development of the lands of the STs by providing minor irrigation and other facilities to the extent possible, ensuring fair prices for minor forest produce, mitigate historical injustice done to the tribal communities living in and around the forest, etc. Intervention in these core sectors was aimed at supplementing efforts of Central Ministries/Departments dealing with their sectoral programmes and State Governments/UT administration and thereby improves the overall human development indices the target group so as to further the process of their socio-economic and political empowerment.

* * * * *

The STs mostly own land, through productivity thereof is extremely low due to practice of rainfed agriculture. Assured irrigation in most of the cases is not available due to undulating terrain and inaccessibility of tribal areas. The Ministry requested all State Governments during the year to prepare specific projects for improving moisture requirement of the tribal lands through appropriate technologies, including watershed, water harvesting structures, minor irrigation, etc. The Ministry has received some proposals from the State Governments of Jharkhand, Rajasthan, Chhatisgarh, MP, Arunachal Pradesh, Karnataka and Andhra Pradesh, etc., and also specific projects for development of land of PTGs like Chenchus. An amount of Rs. 50 crores has been provided by the Planning Commission as additional funds for minor irrigation during 2005-06.

Pending conversion of the forest villages into revenue villages, the Ministry has during the year taken a lead to create infrastructure in and around 2700 forest villages creating basic amenities in terms of roads, drinking water, school building and hospitals, etc. Due to this Ministry's constant pursuasion, the Ministry of E&F have recently vide their circular dated 3.1.2005 accorded one time approval under Section 2 of Forest (Conservation) Act, 1980 allowing diversion of forest lands to Government Departments for taking up these activities. The State Governments have been requested by the Ministry to immediately take steps to identify the infrastructure required to be created in the States and accordingly projectise the same and include on priority for funding. To accelerate the pace of creation of infrastructure in the forest villages, an amount of Rs. 230 crores has been provided by the Planning Commission as additional funds under SCA to TSP for 2005-06.

V. Settling land rights of tribal communities

The rights of forest dwelling Scheduled Tribes who are inhabiting the forests for generations and are in occupation of forestland have not been adequately recognized so far resulting in historical injustice to these forest dwelling Scheduled Tribes who are integral to the very survival and sustainability of the forest eco-system. The Ministry of Tribal Affairs has been mandated to formulate a "Scheduled Tribe (Recognition of Forest Rights) Bill", the main objective of which will be to undo this historical injustice by recognizing and vesting the forest rights and occupation in forest land of forest dwelling Scheduled Tribes who have been residing there for generations but whose rights could not be recorded. The forest rights recognised under the said Bill would include responsibility and authority for sustainable use of forestland, biodiversity conservation and maintenance of ecological balance, thereby strengthening the conservation regime while ensuring livelihood and food security of the forest dwelling Scheduled Tribes. The Ministry expects to introduce the Bill in the current Budget Session, 2005 of the Parliament after completing the necessary formalities.

VI. Comprehensive land based plan for development

For effective and timely implementation of the Common
Minimum Programme of the UPA, the State Governments have been requested to prepare comprehensive land based plans for overall development of the STs by taking up the developmental activities including minor irrigation on lands owned by STs.

VIII. Focus on creation of infrastructure for value addition

It has been decided in the Ministry to focus on creation of such infrastructure in the tribal areas, which enhances production capacity of the land and ensures value addition right at the grass root level. To operationalise the Ministry’s decision of focusing on creation of infrastructure for value addition of the natural resource base, including minor irrigation on the tribal lands, the process of consultation with the State governments at the regional level has also been initiated so as to have State-wise in-depth discussion. The first regional Conference to approve such projects for the Western Region was held at Udaipur on 3.8.2004. The second regional Conference to approve such projects for the Central region was held at Raipur, Chhattisgarh on 10.9.2004. Meetings were also held at New Delhi on 14.9.2004, 15.9.2004 and 22.9.2004 with the States of Orissa, Andhra Pradesh, Assam, Karnataka, Kerala, Manipur, Tamil Nadu, Tripura, Meghalaya and Nagaland for sanction of projects under SCA to TSP and Article 275(1) of the Constitution. This is being done for the first time in 25 years since the scheme was initiated. An amount of Rs.497.00 crores as against the budget of Rs.497 crores has been released to the States under SCA to TSP for taking up community-based income generating activities. An amount of Rs. 330.00 crores has been released under Article 275(1) to the different States for infrastructure development projects and establishment of Eklavya Modern Residential Schools in the country.

IX. Conferment of Ownership rights over MFP to tribals

The State Governments have been asked to confer ownership rights in respect of minor forest produce (MFP), including tendu patta, on the Scheduled Tribes after providing definition of MFP, which should be all the traditional produce being produced by all the tribals, by amending the concerned State Legislations, as provided in the Provisions of the Panchayats (Extension to the Scheduled Areas) Act, 1996. The Ministry has taken up this matter with the Ministry of Environment & Forests, who have drafted a Model State Minor Forest Produce (Ownership of Forest Dependent Community) Bill, 2004 for conferring ownership right of MFP on local communities.
ANNEXURE 6
EXTRACTS FROM INDIA WATER VISION 2025
(Framed by India Water Partnership-IWP)

Vision Elements

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.

Efficient Use of Water Resources

This will entail:

- Improving effectiveness in the use of water.
- Optimizing 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.

Decentralisation and People’s Participation

This will necessitate:

- Increased role of women in decision-making on water use.

Decentralisation – political, administrative ad fiscal.

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.
- Provision of increased storage facilities by arresting run-off/monsoon supplies.
- 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 fertilizer and pesticides on the environment, i.e. the promotion of integrated nutrient and pest management.

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
ANNEXURE 7

WORKSHOPS, NATIONAL CONSULTATIONS AND DISSEMINATION OF THE STUDY COMPONENTS AND MODEL DEVELOPED UNDER CPSP PROGRAMME

Workshops, National Consultations and meetings to discuss the holistic Land and Water use Basin planning model developed under Country Policy Support Program undertaken by ICID with the finding support from The Netherlands Government were undertaken at various events as detailed hereunder:


About 70 participants including experts in the field of Water Resources, Environment and Agriculture, stakeholders, senior officers central and state governments, delegates from China and IWMI. In the workshop two basins of India were selected for taking up studies for assessment for requirement of water for food, people and nature. A team of the National Environmental Engineering Research Institute (NEERI) to study various aspects of the water for nature and a team of the Indian Association of Hydrologists (IAH), commissioned by ICID to analyse and synthesize the information into the basin water balances, and to develop different possible scenarios in an interactive way, taking advantage of the consultations with basin level and state level teams for compiling the required data, were identified.

2. Basin level consultations, 16th – 17th January 2003, Bhubaneswar

About 50 participants including experts in the field of water resources, environment and agriculture, stakeholders, the senior officers central and state governments of Orissa, Jharkhand and Chhatisgarh participated in the consultations (list enclosed). A preliminary assessment of water needs in Brahmani basin, water requirement for riverine ecosystems, study of water balance with progression of time and quality and quantity of pollutant loads for eco-degradation and water pollution sources were presented in the consultation. After discussions the classification of sub-basins, data required etc. for developing model was finalized.


About 50 participants including experts in the field of water resources, environment and agriculture, stakeholders, the senior officers central and state governments of Orissa, Jharkhand and Chhatisgarh participated in the consultation (list enclosed). A preliminary assessment of water needs in Sabarmati basin, water requirement for riverine ecosystems, study of water balance with progression of time and quality and quantity of pollutant loads for eco-degradation and water pollution sources were presented in the consultation. After discussions the classification of sub-basins, data required etc. for developing model was finalized.


About 25 experts from the disciplines of hydrology, agriculture, groundwater, water engineers, policy makers etc. participated. The hydrological model for Sabarmati and Brahmani basins developed by the IAH study team, extrapolation of Sabarmati and Brahmani assessments to other basins and policy related issues highlighted by the studies was discussed. It was decided to modify the studies and present in the national level consultation.

5. Presentation of CPSP studies in a special session, 17th September, 2003, Montpellier, France.

Status report of the CPSP studies was presented in the special session for apprising the office bearers of ICID and other delegates attending the 54th IEC meetings.


The goal of the consultation was to identify country specific options for Integrated Water Resources Development and Management (IWRDM) to achieve an acceptable level of food security and sustainable rural development which socio-economic security and environmental sustainability. More than 70 stakeholders from the disciplines of hydrology, agriculture, groundwater, water resources engineers, policy makers, contributing organizations and members of the consortium for DWFE participated in the event Vice President, Hon.Peter S.Lee, Dr. David Molden (IWMI), Dr.Olivier Cogels (IPTRID) were present. 4 Member delegation from Chinese National Committee of ICID (CNCID) / Chinese Ministry of Water Resources also participated (A list of agencies and experts
attended are given in Annexure 8). The modelling of Sabarmati and Brahmani basin for assessment of water use for nature food and people sectors, extrapolation of assessment of these basins to other basins and policy related issue highlighted by studies were presented during the Consultation.

7. CPSP Preparatory Workshop, Cairo, 3rd August 2004

Invited participants from Egypt, India and Mexico attended this event. Both Chinese and Indian studies were presented besides BHIWA model. The interaction concentrated on how to proceed with CPSP in respect of Egypt and Mexico and BHIWA model capability.

8. Preparatory Meeting by China (CNCID) – 17-18 February 2004, Beijing

Chinese National Committee (CNCID) held a preparatory meeting for organizing a broad based Chinese National Consultation (CNC) under the aegis of Country Policy Support Programme (CPSP) on 17-18 February 2004 at Beijing. The meeting was attended by about 20 participants comprising professionals from CPSP-China study teams. After capturing the essence of BHIWA model capability two independent Chinese teams investigated two river basins chosen for the study purpose viz: Jiaodong Basin representing a water deficit one and Qiantang Basin, a water rich basin.

9. National Consultation on CPSP, China, 7th August 2004

After preliminary studies, a National Consultation was organized on 7 August 2004 at Beijing. About 30 professionals including policy makers participated in the consultation. President, ICID Ir. Keizurul bin Abdullah, Secretary General Mr. M. Gopalakrishnan, Mrs. Qing Liyi, China Program Leader of IUCN and Dr. Shahbaz Khan, Research Director attended the consultation. The application of BHIWA model for Qiantang and Jiaodong basin for assessment of water use for Nature, Food and People, and extrapolation of assessment of these basins to other basins were presented by Mrs. Mu Jianxin and Mrs. Wang Shaoli, respectively. Mr. Li Daixin, Chairman, CNCID highlighted the findings of the studies and their usefulness for policy intervention in the Water Resources Development during Eleventh Five Year Plan of China.

10. DWFE, Stockholm, 15 August 2004

Secretary General, ICID introduced ICID’s initiative to address the challenge faced in respect of water for food and environment in the “Dialogue” Review session organised by IWMI. As partners of the Dialogue process, ICID indicated the need of ‘objective assessment based negotiations’ than subjective approach. ICID’s CPSP initiative helped the cause tremendously. In the Stockholm session, Secretary General Gopalakrishnan brought to focus the ICID’s efforts and trial basin studies both in India and China. Besides, a gist of the outcome of the studies and its relevance to ‘policy support’ was highlighted. It was brought out as to how such efforts could be a meaningful exercise; how best different sectoral interests could be factored in the Basin wise studies and further up-scaling to a National level.

Secretary General also participated in the discussions of Global Water Partnership in Stockholm and provided a brief of CPSP – India, China studies. This study could contribute to the exercise relating to Comprehensive Assessment that GWP attempts, on a national, regional and ultimately global basis.

In the Stockholm International Water Institute World Water Week, a paper was presented by Dr. S.A. Kulkarni, Director-I titled “Assessment of Water Resources at Basin Level – A Land Use Based Approach”. This also highlighted the ICID’s initiative on Challenge program explaining the outcome for Sabarmati Basin in India.


The workshop was attended by 24 professionals comprising wide array of relevant disciplines like engineers, economists, environmentalists, sociologists, policy makers/planners, agronomists from China and India besides experts from ICID, IWMI, IUCN and WWF. Application of BHIWA model to selected river basins of India and China and implications of findings at national level were presented in the workshop. The scenario development and the key drivers of the PODIUMSIM were also discussed. Status report of the CPSP studies in India and China were presented in the Special Session held on 5th September for apprising Office Bearers of the ICID and other delegates attended the 55th Session.

12. 3rd IUCN World Conservation Congress, Bangkok, 19th November 2004

Secretary General, ICID joined the panel on ‘Ecosystem management – River Basin Management’ to consider all the issues faced on balancing needs of water users in river basins. Secretary General brought to the fore the need for an integrated water resources development and management
approach in the River Basin Session. The development of a holistic land use based computer model BHIWA by ICID was explained and how Consultations at Basin level, could help for evolving a national level policy review by proper upscaling of the needs of water for people, food and nature, given the vision needs in the years 2025, 2050.

13. CPSP Orientation Workshop, New Delhi 13-17 December 2004

An Orientation Workshop was organized in New Delhi in December 2004 to explain CPSP approach for decision-making in respect of river basins. The audience comprised Pakistanis and Indians working in different organizations. Experts undertaking similar studies in Mexico and Egypt too joined the discussions. Other participants included experts from agriculture, irrigation engineering, water and power development, and environmental fields.

14. 5th International R&D Conference of CBIP, Bangalore, India 14 February 2005

Secretary General introduced ICID’s initiative to address the challenge of water, food and nature by commissioning the CPSP program and explain the approach to over 300 water experts assembled to consider hi-tech applications in water resources sector. It was brought out as to how a systematic basin by basin study undertaken sequentially can help policy makers to understand the impacts of various scenarios of development that are under consideration.

15. The East African Integrated River Basin Management Conference, Morogoro, Tanzania, 7-9 March 2005

Secretary General ICID, participated in the EARBM Conference and presented a paper besides a PowerPoint presentation on the subject: “An Integrated Water Assessment Model for Future Scenario Studies of Sabarmati River Basin in India”.

16. 2nd International Forum on Partnerships for Sustainable Development, Marrakech, Morocco 21-23 March 2005

In response to an invitation received from UN/Department of Economic and Social Affairs (DESA)/His Highness The Majesty, The King of Morocco, Secretary General, ICID attended the 2nd International Forum for Partnerships for Sustainable Development at Marrakech in March 2005. The focus in the presentation on CPSP was how ICID as a lead investigator partnered with IWMI, IFPRI, FAO and several other Indian as well as international organizations to undertake a study that focused on challenge of water for sustainable development. Amongst other things, the study results enabled the participants appreciate the importance of the policy review co-opting different international and national agencies.

17. 3rd International Conference on Irrigation and Drainage, San Diego, USA, 30 March – 2 April 2005

Secretary General, ICID presented ICID’s CPSP initiative on 30 March 2005 in the USCID Conference. The aim was to introduce the capabilities of BHIWA Model in addressing issues related to food security and environmental sustainability considering together land and water, surface and sub-surface water resources, return flows, interest of both aquatic and terrestrial ecosystem etc.
ANNEXURE 8
INDIAN NATIONAL CONSULTATION - COUNTRY POLICY SUPPORT PROGRAMME (INC-CPSP)
21-22 November, 2003, New Delhi
Agencies and experts who joined the consultation Process

MINISTRY OF WATER RESOURCES, NEW DELHI
A.S. Dhingra, Commissioner, Command Area Development, New Delhi
Chetan Pandit, Member-Secretary, Upper Yamuna River Board, New Delhi

CENTRAL WATER COMMISSION (CWC), New Delhi
R. Jeyaseelan, Chairman, Central Water Commission; Chairman Indian National Committee on Irrigation & Drainage, and Vice President ICID
S.K. Sinha, Chief Engineer, Basin Planning Organisation, New Delhi
V.K. Chawla, Director, Irrigation Planning, New Delhi
A.K. Shukla, Assistant Director, National Water Planning, New Delhi
R.K. Khanna, Director, Environmental Impact Analysis, New Delhi
Rishi Srivastava, Deputy Director, Reservoir Operations, New Delhi
Shakti Sarraf, Deputy Director, Basin Planning, New Delhi
R. Thangamani, Deputy Director, Basin Planning, New Delhi
Sharad Chandra, Deputy Director, Basin Planning, New Delhi

OTHER CENTRAL GOVERNMENT ORGANISATIONS AND INSTITUTES
Dr. D.K. Paul, Assistant Director General, Indian Council of Agricultural Research (ICAR), New Delhi
Dr. A.K. Singh, Project Director, Water Technology Centre, Indian Agricultural Research Institute, New Delhi
Dr. R.P.S. Malik, Fellow, Agriculture Economic Research Centre, Delhi University, New Delhi
Prof. Kanchan Chopra, Professor and Head, Environmental and Resource Economics Unit, Institute of Economic Growth, Delhi
Prof. Kamta Prasad, Chairman, Institute for Resource Management & Economic Development (IRMED), New Delhi
Dr. K.D. Sharma, Director, National Institute of Hydrology, Roorkee, Uttarakhand
Dr. K.K.S. Bhatia, Scientist, National Institute of Hydrology, Roorkee, Uttarakhand
Dr. K.G. Ranga Raju, Deputy Director, Indian Institute of Technology, Roorkee, Uttarakhand
Dr. M.L. Kansal, Associate Professor, Water Resources Development & Training Centre, Indian Institute of Technology, Roorkee, Uttarakhand
Dr. M.V. Nanoti, Head, Geo-Environment Management Division, National Environmental Engineering Research Institute (NEERI), Nagpur, Maharashtra
Dr. S. Devotta, Director, National Environmental Engineering Research Institute (NEERI), Nagpur, Maharashtra
STATE GOVERNMENT ORGANISATIONS AND INSTITUTES


B.G. Upadhyay, Assistant Engineer, Central Designs Organisation (CDO), Water Resource Deptt., Govt. of Gujarat, Gandhinagar

P.B. Pathak, Assistant Engineer, Central Designs Organisation (CDO), Water Resource Deptt., Govt. of Gujarat, Gandhinagar

Dr. E J James, Executive Director, Centre for Water Resource Development and Management (CWRDM), Govt. of Kerala, Kozhikode, Kerala.

Dr. D.H. Pawar, Professor, Faculty of Agriculture, Water And Land Management Institute (WALMI, Govt. of Maharashtra, Aurangabad

B.C. Biswal, Engineer-in-Chief, Rengali Irrigation Project, Department of Water Resources, Govt. of Orissa, Bhubaneshwar

R.K. Gupta, Chief Engineer, Water Resources Department, Govt. of Rajasthan, Jaipur

Dr. Mahesh Gaur, Institute of Environment Management and Sustainable Development (IEMSD), Govt. of Rajasthan, Jaipur

CONTRIBUTING ORGANIZATIONS/DIALOGUE PARTNERS

Dr. Upali Amarasinghe, Senior Regional Researcher, International Water Management Institute, (IWMI) Colombo, Sri Lanka.


Dr. Olivier Cogels, Programme Manager, International Programme for Technology and Research Irrigation & Drainage (IFTRID), FAO, Rome, Italy

CONSULTANTS/NGOs

L.N. Gupta, former Ex.Director, Water & Power Consultancy Services (WAPCOS) and Adviser WAPCOS, New Delhi

A.D. Mohile, former Chairman, Central Water Commission and INCID and Adviser WAPCOS, New Delhi

S.A. Swamy, former Engineer-in-Chief, Delhi Water Supply Undertaking; Consultant, WAPCOS, New Delhi

Paritosh C. Tyagi, former Chairman, Central Pollution Control Board (CPCB), New Delhi.

Prof. Subhash Chander, former Professor Indian Institute of Technology, New Delhi

Prof. P.B.S. Sarma, former Director, Water Technology Centre, IARI, New Delhi.

R. Rangachari, former Member Central Water Commission, New Delhi.

Rajeev Kher, Senior Fellow, Tata Energy Research Institute, New Delhi

A. Mohanakrishnan, Advisor to Govt. (Water Resources) & Chairman, Cauvery Technical Cell, Tamil Nadu, Chennai.

Dr. Subhadarshi Mishra, Managing Director, Spatial Planning, & Analysis Research Centre (P) Ltd., Bhubaneshwar
Dr. B.P. Das, former Chief Advisor, Dept. of Water Resources, Orissa
G.C. Sahu, former Engineer-in-Chief, Govt. of Orissa, Bhubaneshwar
B.J. Parmar, former Secretary, Water Resources, Govt. of Gujarat, Ahmedabad
M.U. Purohit, former Secretary, Narmada & Water Resources Deptt., Ahmedabad
V.B. Patel, former Chairman, Central Water Commission, Ahmedabad
M.S. Billore, former Secretary, Water Resources Deptt., Govt. of Madhya Pradesh, Bhopal
K.R. Datye, Consulting Engineer, SOPPECOM, Mumbai, Maharashtra
Cdr. (Retd.) D.D. Naik, CEO, DD & Associates, Pune, Maharashtra
V.M. Ranade, former Secretary, Dept. of Irrigation, Govt. of Maharashtra, Pune
Dr. Diptiman Bose, Member, Nagrik Manch, Ranchi, Jharkhand

CHINESE NATIONAL COMMITTEE (CNCID), Beijing
Ms. Huang Guofang, Officer, Division of International Cooperation
Ministry of Water Resources (MWR), Beijing
Dr. Liao Yongsong, Ph.D, PODIUM Modeler, China Institute of Water Resources and Hydropower Research, Beijing
Dr. Liu Yu, Senior Researcher, China Institute of Water Resources, and Hydropower Research, Beijing
Liu Xiaoyong, Senior Engineer, General Institute for Water Resources and Hydropower Planning and Design, Ministry of Water Resources, Beijing

Indian National Committee on Irrigation and Drainage (INCID), New Delhi
M.S. Menon, Member-Secretary, New Delhi
R.V. Godbole, Consultant, New Delhi
S.K. Sharma, Advisor, New Delhi

International Commission on Irrigation and Drainage (ICID), New Delhi
Peter S. Lee, Vice President Hon., U.K.
Dr. M.A. Chitale, Secretary General Hon., (ICID), Aurangabad, Maharashtra
Dr. R.S. Varshney, Secretary General Hon., (ICID), Ghaziabad, U.P
Dr. C.D. Thatte, Secretary General, New Delhi
M. Gopalakrishnan, Secretary General – Designate, New Delhi
K.N. Sharma, Secretary, Central Office, New Delhi
S.P. Goyal, Joint Secretary, Central Office, New Delhi
Dr. S.A. Kulkarni, Director I, Central Office, New Delhi
Dr. V.K. Labhsetwar, Director II, Central Office, New Delhi
Policy Interventions and extrapolation to cover other basins

- There is a need to quantify the amount of water that provides goods and services for the eco-system and attribute/allocate it to the nature sector.
- Traditional water resource management techniques should be kept in view as those are time tested.
- More than two third of the water resources of India come from international rivers. It would therefore be necessary to study these basins before deciding on the extrapolation.
- There is no need to provide for meeting navigational requirements.
- Take up one basin for each zone either on the basis of agro-climatic characteristic or per capita water utility.
- Water stress criteria needs re-look because 60% of water resources are available in Ganges and Brahmaputra basins.
- The future developments proposed in a basin should take cognisance of the existing infrastructure.
- There is an apprehension that Rengali reservoir may not get filled up if development for water harvesting taken up on a massive scale and NALCO which is drawing industrial water from Brahmani may suffer.
- Water in the unsaturated zone that is green has been largely neglected in water accounting.
- The criteria of water stress may be different for different countries depending upon their climatic situation, food habits and life styles.
- One more indicator may be added viz., water availability per hectare of cultivable land (including blue water and green water).
- For these two basins, we may try to quantify the amount of water saving due to adoption of measures like crop genetic engineering, precision irrigation and irrigation pricing.

- Like rooftop harvesting for household units or group of houses, can we also think of household sewage treatment system so as to use the treated water for toilet flushing or gardening.
- There is no policy to assess basin wise industrial demand. Normally, industrial use is projected as a country as a whole. Future industry should be established giving due consideration to the available water resources in a basin.
- Roof top water harvesting also contributes to ground water pollution.
- One more indicator of water stress could be the depletion fraction of different basins in determining the water scarcity.
- While projecting irrigation water requirements, efficiency of irrigation should be taken in to account as area under drip and sprinkler irrigation is increasing. Similarly, crop productions in green houses may be sizable in near future.
- Deriving water stress indicators on the basis of two basin situations may not be adequate and appropriate for projection purposes.
- The time has come to take the water right issue squarely. We cannot afford to be ambivalent on this because this is controversial, sensitive and political.
- The salinity increase is to be considered as one of the additional indicator. Particularly, in the coastal belt as salinity ingress and extends up to 25-30 km from the coast. To arrest the salinity, minimum flow in the river is to be maintained and that has to be quantified whether it is 5% or 10% or 20% of mean annual flow.
- Instead of assuming return flows as 10% or 15% or 20%, additional studies may be carried out to assess the return from the surface irrigation.
- Some mention should be there in the report that effective ways should be undertaken to check the population.
Ground water legislation is not being implemented and not being made effective. Strong endorsement is required on ground water regulation.

At present, water needs include the water being wasted. So, we may introduce a concept of artificial scarcity and put some values in the model to see that the needs are not met to some extent and the deficiency is met with by more efficient water use.

EFR is about 10-20 percent in North China and 20-30 percent in South China and EFR is different from downstream to upstream, from river to river, from basin to basin.

China has passed a National Water Law, which is a revised version of the previous law to pursue the sustainable water management to achieve a harmonious co-existence between man and the nature.

While taking the decision just like water harvesting should be site or basin specific. It should not be followed blindly throughout the country, as it is not giving any fruitful results.

Anything less than 1000 sq. km where people’s action, their cooperation will be the dominating factor, we will be calling it a watershed. From 1000 sq. km to 20,000 sq. km and incidentally that is where Sabarmati fits in and also Brahmani is not far away. So these are the types of sub-basins we are calling it where “Area water partnerships” are being promoted for very similar exercises. The present study has been presented as a policy dialogue and it should share with the stakeholder groups.

In each basin there will be roughly five or six issues, which will finally decide the future course to be taken in that basin. All the 20 items/parcels that were listed for the analysis will not be the dominant items in the end. Some of them are more effective; some of them have much less effect as far as the overall water balance is concerned.

The precise basis on which the extrapolation from two basins for the whole country can be made should be clearly brought out.

The traditional assumptions regarding allocations, guidelines, directions have not worked or are not likely to work and therefore we have to device the manners through participatory approach or through regulatory approach, working through the economic mechanism of prices etc., a better system can be devised. We ignored the institutional mechanism.

Even a small land and whatever produces it makes it perpetuate to a family generation after generation. But the same thing does not apply if some one is shifted and employed in the industry. So there are many social issues, which need to be analysed.

In fact, agriculture water price is the lowest among all the water uses. But the problem is that the farmers are not motivated to save water due to low prices. As we have begun to introduce the concept of water rights- farmers will be able to sell their water rights leading to saving in water.

Water Assessment

- In drought prone areas or in drought situations the actual water demand is more, because the effective rainfall is less. This is not reflected in our model.
- There is an apprehension that the average situation considered in the model doesn’t reflect the basin in the total entirety.
- Water is allocated in interstate basin to the state and each state is free to do what it wants with the allocated water. And there is an apprehension that States do not agree to change the allocations in case somebody requires water for specific purpose other than allocated.
- The model results show that the computed values are significantly different from the observed values for the second and third sub-basin, especially the lower basin where much development is expected in future. During discussion it was stated that the model results couldn’t be improved further. In such case, it is suggested that if the model or the modelling methodology cannot be improved then at least it should be accounted how these modelling errors are going to effect the estimations made for different scenarios.
- The calibration results appear a little discomforting when you look at the Sabarmati basin results.
- In both the basins water withdrawals for irrigation have been increased instead of considering increase in performance from the existing irrigation, this should be brought out in the report.
The water balance model should be accompanied by a biomass balance model.

The monthly analysis is not adequate, daily analysis will be useful.

All the scenarios presented assume very small changes in the cropping patterns.

Possibility of diversification of economic activity from agricultural activity can also be thought of, particularly in Sabarmati basin.

There is a need to introduce economic understanding into these hydrologic models otherwise the policy interventions that we get will become very lopsided.

Sabarmati water resource modelling – basin being a drought prone area can we also have an alternative Sabarmati water resource modelling on the basis of 75% available inflows which would give more realistic scenario for the present and future needs.

The flood control projections should also be considered along with other future projections.

There is a need to develop a more sustainable model where water for nature, people and food are linked. And not to look for solutions separately.

Water for Nature

Water for Nature

There is a need to consider water for wetlands, especially coastal wetlands where there are lot of bio-diversity, like mangroves.

Due to transportation there are deposits of nutrients, chemicals, and sediments, which are going to effect bio-diversity of wetlands in the estuarine system.

There is a need for water for the estuarine ecology and navigation in addition to requirement for mangroves and Bithar Kanika areas.

Water harvesting structures or minor irrigation systems should be developed all around the industrial estates or the cities.

Polluted water effluents, after due treatment, should be discharged into the canals or used for irrigation by lifting.

There should be a minimum reference flow and these flows change from month to month, and probably from one flood event to the other to conserve ecology and bio-diversity. There is a need to regulate the frequency of flooding for maintaining morphology.

The need for water for maintaining environmental regime in each basin is to be decided by interdisciplinary group consisting of scientists drawn from bio-diversity, ecology, sociology, hydrology, geomorphology and water resources engineering groups.

At least 5 to 10% of the river flows should be reserved for ecological treatment. In India, there are almost 2 lakh habitats, which have water quality problems, which need to be considered.

Water for food and people also satisfy some of the environmental needs.

Environment in the village areas is more or less good where there are no industries and non-point agricultural pollution but in the urban conglomerate there are problems of environmental degradation. There is a need for action like Bhagidari system in Delhi.

Large irrigation development being planned in Brahmani basin is going to eventually effect the pattern of flow in the early July, August or whole of July which will be detrimental to fish breeding. Such situation happened in Mahanadi, Krishna and Cauvery rivers.

Riparian needs of the flow need not necessarily be an environmental flow.

If the river is allowed to live then it should be able to support life and also it should be able to withstand adverse circumstances like onslaught of pollution, or excessive abstraction. River should be envisaged as a living entity just like a forest.

Many times zero effluent and its impact on the total demand on industrial water supply has not been reflected.

The possibility of using dams/ storages to convert those rivers, which are not perennial into perennial rivers, may be explored.

Basin level organisations are required to consider inter-disciplinary approach; we have no such institutions for water allocations. We should involve different stakeholders to enter into a very comprehensive dialogue mode involving scientists, engineers and planners.
There are complex models which are required to be operated but EFR finally has to be decided by negotiations between stakeholders and will have to find the planning and management strategies to meet those EFR needs. Institutes like NIH and NEERI should immediately start working on such problems. Set up new divisions and take up joint studies and such case studies, which gives some insight.

In regards to EFR, it will not be simple percentage but it would have been natural hydrological regime and natural regime of the flora and fauna.

The aquifers have been mostly untouched in the study, as it is felt that there is no ecology connected with ground water and it does not deserve so much of attention. Since minimum flow in the river is derived from the ground water and if ground water is excessively used and depleted below ground water table there will be naturally pollution in the minimum flows.

Historically EFR has been referred as minimum flows, or mandatory flows for down stream uses which included not only the environmental needs but also the down stream drinking water needs, down stream abstractions for beneficial uses, the navigational needs and also for maintaining, in case where there are, international agreements on trans-boundary flows.

Every country has a different perception on what is called as EFR or MFN.

Man-made wetlands are also to be taken care of similar to natural wetlands.

Mangroves are spread in mostly tropical climate regions. India has got a large quantum, almost 5th in the whole hierarchy of mangroves. And 7.73 million hectares, almost half of the mangroves of the world are accounted in the countries like Indonesia, Brazil, Nigeria, Australia, Cuba, India and Mexico. Brahmani mangroves have been attributed with preventing cyclone damage and this has been stated by Dr. Das in some of his presentation and in Sabarmati basin there are hardly any mangroves.

In India, the pollution in river is contributed by the municipal source to the extent of 45%, and by industrial source about 45% and these situations can be improved if pollution is controlled at the source. In such situation there is no need for EFR to be released separately.

**Domestic & industrial water needs and issues**

- Water quality varies in space and time we should consider the water quality at the tap level. Generally the reliability of the water supply system is very poor.

- The major problem is the information about the existing network. In Delhi, there is no information about the existing water supply schemes. So, it is very difficult to know from where the pipeline is going, how the flow is taking place, what are the head losses, which are taking place. One more problem is that, it has been suggested that we should provide separate system of drinking water as well as for flushing and washing. But is it economical or feasible to provide the double network? Then if you can not provide the water security for the drinking purpose then how we can talk about the water security for the food. That means we should give the first priority to the water for people and if we achieve that water security for the people, and even if we are providing the water security for the agriculture or irrigation, say by 90% that will be a big achievement.

- How to finance sewage and its treatment for recycling: Given the experience that we have had in 54 major cities in this country, not just Pune, the good old municipal system of centralized sewage treatment is failing and will continue to fail. The monitoring mechanism as well as the concern of the controlling authorities is not adequate. And think of privatising the utility of the river systems within the cities and compelling the privatised BOT operators to finance the sewerage systems. The remunerative part of it as far as BOT operator is concerned could come from the river navigation requirements which could be met, provided there is a freedom for him to use the river. The other part is that can we encourage the use of treated effluent directly for irrigation? The sewage for irrigation is found to be extremely efficient in terms of productivity and lower use of fertilizers and the higher yields level etc. as well as the soil compositions, which have resulted due to use of sewage through the river water is well proven and well studied.

- Issue of socially acceptable privatisation and institutional arrangements that go with it to assure to every individual the minimum basic service concurrently with that making recovery possible.
And linking institutional innovations with reorientation of the system of public financing.

- ‘Reed technology’ and some studies, which have been done in the Shipra River, near Ujjain can be used to purify the waste water.

- We may encourage the use of treated effluent directly for irrigation thereby improving both the quality and quantity of the river water. Farmers, in case of scarcity, can use untreated water for growing crops.

- 50 lpcd is essential requirement for drinking, minimum health and hygiene and it should attract the highest priority and anything above 50, say 50 to 150 or 50 to 200 that need not get the highest priority.

- There are enough examples of using effluent water for irrigation in India, in particularly in Gujarat. Israel has got the primary treatment, secondary treatment and tertiary treatment and thereby uses can be decided and monitored also. This experiment may be tried in India to solve the problem of supply of water in Sabarmati, which is a water deficit basin.

- As a matter of information for the dual plumbing system, Mr. Patel had made some analysis and the additional investment was coming only 5000 rupees per a dwelling unit. Two-pipe supply system can be introduced. Collect the kitchen and bathroom washings, just screen and then reuse for flushing. Both are nearly equally 50 litres and cost of this very simple treatment will not be even Rs.0.50 kilolitre. So, the investment is less than Rs.5000 the treatment cost is Rs.0.50 per kilolitre and the fresh water saved is 50 litres per person per day. Fresh water for health related uses would be 50 to 80 litres per person per day and the rest will be either through reuse or use of inferior quality water.

- New rules have been introduced where roof top harvesting is made compulsory in the urban areas. The cost of rooftop harvesting as compared to the volume of water that is harvested is significantly high. It comes more than Rs.40 per cubic meter of water. Many institutions have installed this rainwater harvesting system and nobody is using that ground water. They keep on drawing on public system. So, suggestion is that instead of encouraging rooftop harvesting in the cities, that money may be used in rural areas for recharging. The volume recharged will be ten times. This scheme is similar concept to the environmental forest department scheme of compensatory afforestation. So we call it compensatory recharge scheme to be made compulsory both for industrial uses and for the urban water supply systems.

- After proper treatment of wastewater and part of it must go into the river basin as dilution water, otherwise the basin will get dry.

- Treated effluent can be put it in to a canal so that it can be diluted and can be used for irrigation.

- It is estimated that there is a possibility to irrigate about 1 million hectares in India through treated wastewater as per standards.
REFERENCES


**Anicut:** A barrier across a stream for the purpose of diverting part or all of the water from a stream into a canal is called ‘anicut’ (weir). It may incidentally store water for emergencies.

**Aquatic:** Growing in, living in, or frequenting water.

**Aquifer:** A porous geological formation, which can store an appreciable amount of groundwater and from which water can be extracted in useful quantities.

**Arable:** Land suitable for cultivation by ploughing or tillage, does not require clearing or other modification.

**Arid:** An area or climate that lacks sufficient moisture for agriculture without irrigation. According to Thornthwaite, areas having moisture index below –40 Thornthwaite moisture index.

**Artificial groundwater recharge:** Replenishment of groundwater storage by injection, deep percolation or surface flooding.

**Base flow:** Streamflow coming from groundwater seepage into a stream.

**Basin:** Area drained by a river or its tributaries upto its common terminus.

**Beneficial/Non-beneficial Evapo-transpiration:** The evaporation, which provides goods and services to mainland through food production, or through support to ecosystems is considered beneficial. Where no significant goods and services are obtained as through evaporation from soils or from patchy barren lands, which may have few weeds etc., are, considered as non-beneficial.

**Check dam:** Small dam constructed in a gully or other small water course to decrease the stream flow velocity, minimize channel scour and promote deposition of sediment.

**Consumptive use:** That part of water withdrawn that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment. Also referred to as water consumed.

**Conveyance loss:** Water that is lost in transit form a pipe, canal, or ditch by leakage or evaporation. Generally, the water is not available for further use; however, leakage from an irrigation ditch, for example, may percolate to a ground water source and be available for further use or may be recycled for reused.

**Crop rotation:** The practice of alternating crop types to maintain fertility levels, improve soil condition, avoid insect or disease infestations, etc.

**Crop water requirement:** The total water needed for evapo-transpiration, land preparation in the case of paddy and other requirements (leaching etc.) from planting to harvest for a given crop in a specific climate regime, when adequate soil water is maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield.

**Crop-coefficient:** It is the ratio coefficient between ET crop and reference evapotranspiration ET₀. Crop coefficient varies with the stage of the growth of the crop and is also dependent on the humidity and wind conditions under which the crop is being grown.

**Cropland:** Land regularly used for production of crops.

**Dead Storage capacity, or Dead Storage:** The storage volume of a reservoir measured below the invert level of the lowest outlet and the minimum operating level.
Dependable yield: The value of yield for which water resource projects for water supply, irrigation and hydropower are designed.

Discharge site, Gauging site: A selected site on a stream for making observation of velocity and area of cross section with a view to determining the discharge.

Discharge, or Rate of flow: The volume of water, which flows past a particular cross section of a channel or conduit in a unit of time.

Domestic water use: Water used for household purposes, such as drinking, food preparation, bathing, washing clothes, dishes, dogs, flushing toilets, and watering lawns and gardens.

Drainage area, Catchment area, Catchment Watershed: The area from which a lake, stream or waterway and reservoir receives surface flow which originates as precipitation. Also called ‘watershed’ in American usage.

Drainage basin: Land area where precipitation runs off into streams, rivers, lakes, and reservoirs. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Large drainage basins, like the area that drains into the Mississippi River contain thousands of smaller drainage basins. Also called a “watershed.”

Drainage: The natural or artificial removal of excess surface and ground water from any area into streams and rivers or outlets.

Drip irrigation: A method of irrigation where water slowly drip onto crop root zone. Drip irrigation is a low-pressure method of irrigation and less water is lost to evaporation than high-pressure spray irrigation.

Dry farming: Agriculture practiced on non-irrigated land and dependent upon natural precipitation and its retention and distribution in the crop root zone.

Ecology: The study of the relationships of living things to one another and to their environment.

Effective rainfall: 1- Rain that produces runoff. 2- in irrigation practice, that portion of the total precipitation, which is retained by the soil so that it is available for use for crop production. 3- In geo-hydrology, effective rainfall is defined as that part of the total precipitation that reaches the groundwater (recharge).

Effluent—water that flows from a sewage treatment plant after it has been treated.

Environmental Impact: An effect of any kind on any component or the whole of the environment. Assessment of the impact generally involves two major elements – a quantitative measure of magnitude and a qualitative measure of importance.

Environmental Flow Requirement: Water needed for maintaining aquatic and terrestrial systems in a good health.

Environmental pollution: the contaminating or rendering unclean or impure the air, land, waters, or making the same injurious to public health, harmful for commercial or residential use, or deleterious to fish, bird, animal or plant life.

Estuary: A passage where the tide meets a river current; especially an arm of the sea at the lower end of a river; a ‘firth’.

Evaporation—the process of liquid water becoming water vapor, including vaporization from water surfaces, land surfaces, and snowfields, but not from leaf surfaces.

Evapotranspiration, or Consumptive use of water: The quantity of water used by the vegetative growth of a given area in transpiration or building of plant tissue and that evaporated from the soil or from intercepted precipitation on the area in any specified time. It is expressed in water-depth units or depth-area units per unit area.

Exponential index for actual ET estimation: An index to slightly modify the decay of soil moisture through evaporation.

Fallow land: Land which (during the relevant period) has no crops

Freshwater: Water with salinity less than 0.5 parts per thousand.

Groundwater balance, or Groundwater budget: A systematic review of inflow, outflow and storage as supplied to the computation or groundwater changes.

Groundwater confined: Ground water under pressure significantly greater than atmospheric, with its upper limit the bottom of a bed with hydraulic conductivity distinctly lower than that of the material in which the confined water occurs.

Groundwater recharge: Replenishment of groundwater supplies in the zone of saturation, or addition of water to the groundwater storage by natural processes or artificial methods for subsequent withdrawal for beneficial
use or to check salt-water intrusion in coastal areas. 2- Also the process of replenishment or addition, of the quantity of such water.

Groundwater table: Upper boundary of groundwater where water pressure is equal to atmosphere, i.e. depth of water level in a borehole when ground water can freely enter the borehole.

Groundwater: The water that occurs in the zone of saturation, from which wells and springs or open channels area fed. This term is sometimes used to also include the suspended water and as loosely synonymous with subsurface water, underground water or subterranean water.

Groundwater recession co-efficient: The constant of proportionately which, when multiplied by the groundwater storage (above the ‘no base flow’ datum) indicates the outflow from the groundwater. In BHIWA Model the groundwater storage is assumed to be a ‘linear reservoir’. The recession co-efficient will have a dimension of T\(^{-1}\).

Hot weather: Crop season from February to May

Humid: An area or climate that has more moisture than the actual agricultural requirement and where drainage facilities are generally essential to get rid of surplus moisture. According to Thornthwaite, areas having moisture index above 10 Thornthwaite.

Hydrologic Cycle: The circulation of water from the sea, through the atmosphere, to the land, and thence, often with many delays, back to the sea or ocean through various stages and processes as precipitation, interception, runoff, infiltration, percolation, groundwater storage, evaporation and transpiration, also the many short circuits of the water that is returned to the atmosphere without reaching the sea.

Hydrological models: A simplified representation of a hydrological system leading to an acceptable simulation of the physical and other processes in hydrology.

Industrial waste: Any solid, semi-solid or liquid waste generated by a manufacturing or processing plant.

Industrial water use: Water used for industrial purposes in such industries as steel, chemical, textiles, paper, and petroleum refining.

Infiltration: 1- The flow or movement of water through the surface into the soil body or ground. 2- The absorption of liquid water by the soil, either when it falls as rain, or when applied as irrigation or from a stream flowing over the ground. 3- Flow from a porous medium into a channel, pipe, drain, reservoir or conduit.

Infiltration volume: Volume of infiltrated water.

Integrated river basin management: The process of formulating and implementing a course of action involving natural, agricultural, and human resources of a river basin therewith taking into account the social, economic and institutional factors operating a river basin to achieve specific objectives. It signifies the interactions of components and the dominance of certain components in the particular area.

Intra-annual fluctuations: Fluctuation within a year.

Irrigation potential: Total possible area that can be brought under irrigation, in a river basin, region or country, from available water resources, with designs based on what may be considered as good technical practice known at the time of assessment of the potential.

Irrigation water use: Water application on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands, such as parks and golf courses.

Irrigation: The controlled application of water for agricultural purposes through manmade systems to supply water requirements not satisfied by precipitation.

Kharif: Summer crop and Monsoon Crop - season from June to September

Land-use pattern: The area design or arrangement of land uses, major and minor, and of operation units convenient for cultivation.

Live storage: That part of the conservation storage of a reservoir which is between the full reservoir level and the level of the lowest outlet to be operated for delivering water for any use.

Mean annual precipitation: The average over a sufficiently long period of years of the annual amounts of precipitation so there nearly true representative value of the mean is obtained.

Mean annual rainfall: The mean of annual rainfall observed over a period, which is sufficiently long to produce a fairly representative mean value.

Mean annual runoff, Mean monthly runoff: The value of the annual volume of water discharged by the stream
drainage of the area, the period of observation being sufficiently long to secure a fair mean; similarly for 'mean monthly runoff'.

**Micro-irrigation:** A method of irrigation in which water is applied to the plants' root zone, in small but frequent quantities, in such a way as to maintain the most active part of the soil at a quasi-optimum moisture.

**Natural Induced recharge:** It is that portion of water, which gravitates to the zone of saturation under natural conditions. In the BHIWA model, a provision has been made for recharge from the river to the groundwater, either through natural or through forced recharge. The provision is to be made by the user for balancing the groundwater regime; user may also change the irrigation area etc. for using this provision.

**Net irrigation requirement:** Irrigation requirement at the head of irrigation farm and is equal to consumptive use plus percolation minus effective precipitation, plus water needed for field preparation, leaching etc. or net duty of water when the latter is expressed in similar units.

**Non-beneficial consumptive use:** The water consumed by native vegetation, evaporated from bare and idle land surfaces and from water surfaces.

**Per capita use** – the average amount of water used per person during a standard time period, generally per day.

**Percolation** – The movement of water through the openings in rock or soil.

**Perennial:** The crop period extends in three seasons

**Potential evapo-transpiration:** The amount of water that could pass into the atmosphere by evapo-transpiration if the amount of soil water were not a limiting factor.

**Potentially utilizable water resource (PUWR):** The amount of the AWR that is potentially utilisable with technically, socially, environmentally, and economically feasible water development program.

**Precipitation:** The total measurable supply of water of all forms of falling moisture, including dew, rain, mist, snow, hail and sleet; usually expressed as depth of liquid water on a horizontal surface in a day, month, or year, and designated so daily, monthly or annual precipitation.

**Quick run-off:** That part of the rainfall, which flows into surface stream without passing through groundwater. As used in BHIWA, the term also includes the interflow.

**Rabi:** Winter crop - season from October to January

**Rain:** Precipitation in the form of liquid water drops greater that 0.5 mm.

**Rainfall intensity:** The rate at which rainfall occurs expressed depth units per unit time. It is the ratio of the total amount of rain to the length of the period in which the rain falls.

**Rain-fed:** Crops which are grown on natural rainfall

**Reference evapotranspiration (ETo):** The evapo-transpiration rate from a reference surface, not short of water is the reference crop evapo-transpiration or reference evapo-transpiration and is denoted as ETo. The ETo is climatic parameters and can be computed from weather data. ETo expresses evaporating power of the atmosphere at a specific location and time of the year and does not consider crop characteristics and soil factors.

**Replenishable groundwater:** A dynamic groundwater potential available in aquifer.

**Reservoir capacity, Gross capacity reservoir, Gross storage, or Storage capacity:** The gross capacity of a reservoir from the riverbed up to the retention water level. It includes active, inactive and dead storages.

**Return flow:** The drainage water from a particular withdrawal that flows back into the system where it can be captured and reused, or recycled within the system.

**Runoff:** 1- Portion of the total precipitation from a given area that appears in natural or artificial surface streams. 2- Also the total quantity of runoff during a specified period. 3- The discharge of water in surface streams above a particular point. 3. Runoff is the surface and subsurface flow of water.

**Saline soil:** A soil containing sufficient soluble salts to impair its productivity. The electrical conductivity of the saturation extract is greater than 2 mmhos per centimeter at 25°C. Crop plant growing is mostly inhibited in saline soils.

**Saline water:** Water, which contains moderate concentration of total dissolved salts.

**Salinity:** The relative concentration of salts, usually sodium chloride in given water. It is usually expressed in terms of the number of parts per million of chlorine (CI).

**Sewage effluent:** The liquid and solid waste carried off with water in sewers or drains.
Soil moisture capacity: The capacity of the soil to hold the water within soil against gravitational force.

Sprinkler irrigation: A method of irrigation under pressure in which water is sprinkled in the form of artificial rain through lines carrying distribution components: rotary sprinklers, diffusers with permanent water streams, perforated pipes.

Stream flow: The water discharge that occurs in a natural channel. A more general term than runoff, stream flow may be applied to discharge whether or not it is affected by diversion or regulation.

Subarid or Semiarid: A term applied to an area or climate, neither strictly arid nor strictly humid, in which some selected crops can be grown without irrigation. According to Thornthwaite, areas having moisture index between −20 and −40 Thornthwaite moisture index are classified as semi arid areas.

Subhumid, or Semihumid: A term applied to an area or climate that has on the whole sufficient moisture to support all crops but irregularity of precipitation during the year making it essential to provide irrigation facilities to raise better crops. According to Thornthwaite, areas having moisture index between +20 Thornthwaite moisture index are classified as sub-humid areas.

Swamp: Wet spongy ground with fully saturated subsoil.

Taluka: A subdivision of a district

Transpiration: The emission or exhalation of watery vapour from the living plant.

Two seasonal: Crop period extends to next season.

Water balance, or water budget: A systematic review or inflow, outflow and storage as applied to the computation of changes in the hydrologic cycle. Always referred to a specific time period like day, week, month, season or a year.

Water table: The upper surface of a zone of saturation, where the body of groundwater is not confined by an overlying impermeable formation.

Waterlogging: State of low land in which the subsoil water table is located at or near the surface with the result that the yield of crops commonly grown on it is reduced well below the normal for the land, or, if the land is not cultivated, it cannot be put to its normal use because of the high subsoil water table.

Wetcrop: Crop, which depends on high doses of irrigation for its growth.