

# **INDIA: National Hydrology Project**

**Draft Report: May 2016**

## **Environment Assessment**

**Ministry of Water Resources & Ganga  
Rejuvenation**

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# 1 CHAPTER 1: PROJECT DESCRIPTION

## 1.1 Background

1. India is the world's 9<sup>th</sup> largest economy<sup>1</sup>, second largest populated country; and is among the fastest growing economies. The current growth rates of 7.4 (in 2014) and 7.5 (in 2015 projected) is the fastest among major countries, and this growth rate is expected to sustain in near future. Between 2005 and 2010 alone, India's share of global GDP increased from 1.8 to 2.7 percent, and 53 million people were lifted out of poverty. Over the last two decades, progress toward many of the Millennium Development Goals has been creditable given the sheer scale of the challenge, including in universal primary education, sustainable access to safe drinking water, reduction in maternal mortality. Continuing this economic growth, expansion of urban-industrial activity, diversification of the economy and skilling of the workforce provides India an opportunity to reduce extreme poverty below 5% by 2030, a reduction of 190 million from the global poor (equivalent to the contribution of China in reducing world poverty in the last two decades).

2. However, poverty still remains widespread, and India still has the largest share of the world's poor. Each of the seven low-income states<sup>2</sup> has poverty rates that are two to three times higher than those of the more advanced states. Poverty reduction in the poorest states—which are also the most populous—has been slow. Urbanization is a process in transition (with different scale and scope among the states), and is not yet a quick way out of poverty. Consequently, 65 percent of the population remains in rural areas and urban fringes. The mainstay in the rural income - agriculture contributes 12.3 percent of the national economy, but employs 53 percent of all workers. As a result 4 out of 5 of India's poor live in the rural areas.

3. India had once witnessed very significant changes in the agricultural sector. Called "India's Green Revolution", the changes that occurred mainly through the 1970s and 1980s transformed the nation from one that was characterized by chronic famines and dependence on food imports into one that is not only self-sufficient in food but also a major exporter of agriculture produce (over USD 44 billion per year<sup>3</sup>). A major input to the "green revolution" was irrigation, which had gradually expanded to 103 million hectares of cropland. Some substantial investments in water resources infrastructure over the last 50 years helped eliminate droughts and famines; and also provided the basis for broad-based development. Notwithstanding, for some years now agriculture sector performed below expectation, and improved performance in agriculture is crucial for lifting most people out of poverty.

4. Lifting people out of poverty, however, is not enough. Even above the threshold (defined as consumption growth of the bottom 40 percent of the population), a large number of people, especially in rural areas, have consumption levels that are very close to the poverty line. Minor shocks—illness, poor crop yields, indebtedness, high inflation—can easily push them below the poverty line. Evidences show that majority of these potential minor shocks for the mainstay agriculture sector in the rural areas arise owing to hydro-meteorological conditions: crop failures and damages due to droughts and floods or variation in precipitation; illness owing to water-borne diseases and water pollution or lack of access to safe water; low crop yield due to lack of timely availability of appropriate quantity of water to be accentuated by climate change induced impacts. Addressing these issues are indeed required to achieve an acceptable degree of shared prosperity.

1. \_\_\_\_\_

<sup>1</sup> In nominal GDP terms, India has a share of 2.7 percent of world GDP. In GDP (PPP) terms, India is the third largest economy having 6.8 percent of world's GDP (PPP).

<sup>2</sup> Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, and Uttar Pradesh.

<sup>3</sup> Food export has increased substantially in the last 10 years.

5. Water resources endowment in India (4.3 percent of annual global water resources replenishment) was favorable, as a whole. However, population pressure (owing to 17.5 percent of global population) and a variety of geographic settings (from hills to deserts, steep high altitude to large deltaic flats, monsoon inducing foothills to large tracts of ‘rain shadow’ areas) makes India vulnerable. Three-fourth of its population lives in water stressed condition having less than 2,000 m<sup>3</sup> per year, while one-third, or nearly 400 million people have less than 1,000m<sup>3</sup> per year (nearly half of the population of all water-stressed countries). Several assessments suggest that demand for freshwater will outstrip supply by 2030. The rapid reduction in the water security is further compounded by capacity to store not more than 15 percent of the mean annual flow, which makes it impossible to adapt to the huge seasonal and inter-annual variations in precipitation. India now identifies water as the most crucial development and adaptation challenge, which has the potential to make or mar the “Indian story”.

6. The country had recognized the enormity of the challenge for some time, and has tried a number of measures. The initiatives include: bringing more areas under public surface irrigation, improving efficiency of public surface irrigation, improving water use practices in agriculture, crop diversification; and research and extension services associated with all above. Bank has been a partner to the government in most of these initiatives. Notably, the importance of information systems and information services for managing water resources in the country had gained traction since mid-1990s, and now gained a prominence. The country set up its ambitious program of establishing improved water resources data collection networks and data handling processes through two Bank-financed projects during 1995-2014 (the Hydrology Project, and the Hydrology-II Project). Given that future challenges are high, and national development is at stake, the government is committed in building an augmented country-wide hydro-meteorological information system and service (replicating and strengthening the achievements of the earlier projects), to appropriately inform the process of transformation that is required in management of water resources in India.

## 1.2 Sectoral and Institutional Context

7. Water is basically a state subject and the Union of India’s role comes in only in the case of inter-state river waters or river valleys. The Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR, RD&GR) is the apex body responsible for the development and management of the water resources of the country, with the Central Water Commission (CWC), and Central Groundwater Board (CGWB) as key technical organizations. The GOI plays a major enabling role in the institutional and policy environment for Water Resources Management as part of its development strategies. MoWR, RD&GR formulates legislation, policies, strategies and operational guidelines for the development and management of water resources. These include the National Water Policy, the National Hydro-meteorological Data Dissemination Policy, and the relevant sections of the Twelfth Five Year Plan. The Union Government has also enacted laws on environment and pollution which indirectly influence water use, including ground water and its exploitation. CWC, CGWB and the Central Pollution Control Board (CPCB; administered by Ministry of Environment, Forests and Climate Change) are responsible for monitoring surface water, groundwater and water quality, respectively at the macro and interstate levels.

8. At the same time, the state agencies play a major role in the preparation and implementation of development projects relating to flood protection and flood forecasting, irrigation and drainage, water supply, monitoring of drinking water, and the collection of hydro-meteorological data. The agencies with primary role of hydro-met monitoring include irrigation/water resources departments, groundwater departments, drinking and water supply (water quality) and, in some cases, central and river basin organizations. River basin organizations are responsible for monitoring rivers and reservoirs under their jurisdiction, as well as reservoir operation, flood control and hydropower generation. In each state there are several Acts dealing with water use relating to irrigation, command area development, maintenance and use of canals and tanks. In most of the states, roles and responsibilities are fragmented across multiple agencies thereby raising coordination and data sharing issues. Overlapping jurisdictions of states and the center calls for a consensus from the State Governments involved, as a pre-condition for any leading role by GOI

relating to water resources management for which information management is no exception. Further, the local self-government of the village, panchayats and municipalities are also empowered by the State Governments to assume functional responsibilities of several aspects of water use.

9. Renewed political commitments, at all levels, on flood management have provided a strong basis for wider consultations for an appropriate and adequate information system. Though water allocations and rights overshadow the establishment and functioning of a realistic and transparent information system, there has been an increasing realization among states about the need for such a system to model and run inclusive river basin operations with all occupying states within multi-state river basins. No one is disputing the mission critical aspects of a robust information system for flood management and enhanced impacts of water resources development.

10. Acknowledging that a country-wide information system is central to effective management of water resources, a comprehensive National Hydro-meteorological Data Dissemination Policy (2013) was introduced to facilitate the exchange of data and information among all national and state agencies. This policy entitles any web-registered user to freely download all unclassified hydro-meteorological data hosted on the India-WRIS website. Implementation of this policy assumes a much greater significance in the context of the new GOI “Digital India” initiative which proposes to e-connect government departments and citizens for effective governance.

11. Initiating a number of critical investments supporting the development and implementation of comprehensive hydro-meteorological monitoring infrastructure, the GOI implemented the National Hydrology Project Phase I (HP1, 1996-2003) and Phase II (HP2, 2006-2014) with the support of the World Bank. The project helped India’s southern (Peninsular) states and the states of Himachal Pradesh and Punjab, to build a comprehensive Hydrological Information System (HIS) and to standardize databases and decisions support systems for river basin operation, planning and management. HIS or Water Resources Information System (WRIS) is an integrated system for reliable, comprehensive and timely hydrological and meteorological data. The project built scientific hydrological and meteorological observation networks for both surface and groundwater data (quantity and quality), established data processing and data storage facilities, set up reliable data communication arrangements, and trained manpower for operations and user support.

12. For the first time in the country, a culture of hydro-meteorological monitoring was introduced through the project. Moving forward, the second phase of the project enabled a paradigm shift in hydro-informatics and operational water management, migrating from manual monitoring to automatic real-time monitoring and transmission, discarding data secrecy for wider data sharing, and from simplistic operational management of water resources infrastructure to more sophisticated and effective operation management of key reservoirs. The project supported establishment of Hydrology data centers and modernization of practices in design, operation and planning units of various water resources departments. The state departments have been transformed to use river basin approach. The HIS armored with modern software tools de facto provided backend support for designing structures and in many states for clearing new projects as well as pointing out alternate cost effective investments. The real-time monitoring and decision support systems for reservoir operation and for water management, though established in limited locations, proved to be very effective in reducing flood damages and improving water resources management.

### **1.3 Objectives of the Project**

13. The project is closely aligned with GOI priorities set for the water sector in the 12<sup>th</sup> Five Year Plan (2012-2017) which has identified a paradigm shift in the management of water resources in the country and one of the key areas identified for such improvements is improved systems for water related data collection and management as also transparency in availability of data. It also identified renewed focus on non-structural mechanisms for flood management and underpinned the need for a new program of aquifer mapping. A working group for the 12<sup>th</sup> FYP, recognizing the efforts done under Hydrology Project,

identified the need for a national data network and recommended for the design of an integrated and digitized National Water Resources Information System. The 12<sup>th</sup> FYP recognizes the value of investing in improving information and knowledge on water resources for improving efficiency and sustainability of water use in the country.

14. The World Bank's Country Partnership Strategy for India (FY 2013-2017) is in alignment with GOIs development vision for faster, sustainable and more inclusive growth. The project will help the country closely monitor the depletion of scarce natural resources like water, growing water scarcity, receding ground water aquifers and water pollution resulting from urbanization and economic growth. It identifies India as the second most vulnerable country in the world with the needs for enhanced disaster risk management especially in agriculture and water intensive sectors. In addition, the project will build state and national capacities for the management of irrigation systems and decentralized management of irrigation tanks, improving the productivity of rain fed agriculture through increased water use efficiency. The project will also contribute to strengthening regional integration owing to its river basin approach which will allow integrated management of water resources. Moreover, low income and special category states are also included in the project. In order to improve the livability of cities and villages, water quality monitoring would help reduce water resource degradation. The project will also focus on facilitating the exchange of knowledge and experience, within the region and beyond, to learn from international good practices.

### 1.3.1 Project's Specific Objectives

15. The proposed Project Development Objectives (PDO) is to **improve** the *extent* and *accessibility* of water data and information and **strengthen** the *capacity* of water resources planning and management institutions in India.

### 1.3.2 Project Beneficiaries

16. The project has three groups of direct beneficiaries: I) Central and state agencies responsible for surface and/or groundwater planning and management, including river basin organizations; II) Central agencies responsible for meteorology, survey and remote sensing which provide support to water resources management; III) Rural and urban water users and those affected by floods and droughts, especially poor, small and marginal farmers.

17. Indirect beneficiaries include the many stakeholders across the energy, environment and agriculture ministries; research and educational institutions; students and researchers, NGOs, civil society organizations and the private sector.

### 1.3.3 Results Indicators

18. The key result indicators to measure the achievement of the project activities are:

- (i) Number of operational hydromet stations improved or established;
- (ii) Number of users accessing project services;
- (iii) Number of times project knowledge products are accessed/downloaded;
- (iv) Number of operational WRM institutions (Operational means the institution which has working cell for Flood/River basin assessment and/or irrigation operation and management or similar);
- (v) Percent of implementing agencies with satisfactory benchmark performance levels (fully institutionalizing hydro-meteorological information system and providing cross-cutting support to all agencies within the state/basin for planning, designing, resource allocation, disaster management, studies and research);

- (vi) Number of vulnerable population (including women), from improved reservoir management, improved irrigation scheme management and improved flood forecasts.

## 1.4 PROJECT DESCRIPTION

### 1.4.1 Project Area

19. This a national project that will cover all of India. All states and Union Territories will participate in the project given their constitutional mandate for water resources management. Central agencies will also participate given their role in providing technical expertise and leadership in development of National water information base and water resources assessment, and their role in the coordination of water management issues across states in a Basin and their critical role in the development of a river basin approach to water resources management.

### 1.4.2 Project Scope

20. The project builds upon the prior investments under Hydrology Project I and Hydrology Project II, which were predominantly implemented in the peninsular states of India. These established improved infrastructure for measurement and standardized database management of water resources. It also developed key tools, protocols and softwares to validate the quality of data and to manage data storage and dissemination. The tools and decision support systems were also introduced that enabled use of data/information in planning and operation of water resources management infrastructure in selected river basins. The proposed project seeks to further strengthen evidence based decisions making process in water resources planning and operational management across India using latest technology and tools.

### 1.4.3 Project Components

21. Evidence based decisions require not just improved water information products but also enhanced institutional capacity – both technical capacity and policy and planning capacity (Figure 1). Improved water information products (including water resources assessments, water accounts and audits, scenario analyses and option assessments, forecasts and early warnings) requires improved water data and improved tools (analytical and decisions support systems) to transform data into information. The project thus spans the value chain from water resources data to decision making capacity in water resources development and management through informed planning and operation (Figure 1). Beyond the project, this is expected to lead to improved water resources decisions generating greater economic, social and environmental benefits.

22. The project will have four components: (A) Water Resources Data Acquisition, (B) Water Resources Information Systems, (C) Water Resources Operations and Planning systems; and (D) Institutional Capacity Enhancement. These components (and their sub-components) map across the conceptual framework, with Component C spanning the application of systems/tools to generate water information products, and Component D encompassing strengthening of both technical and planning/policy capacity (Figure 1.1).

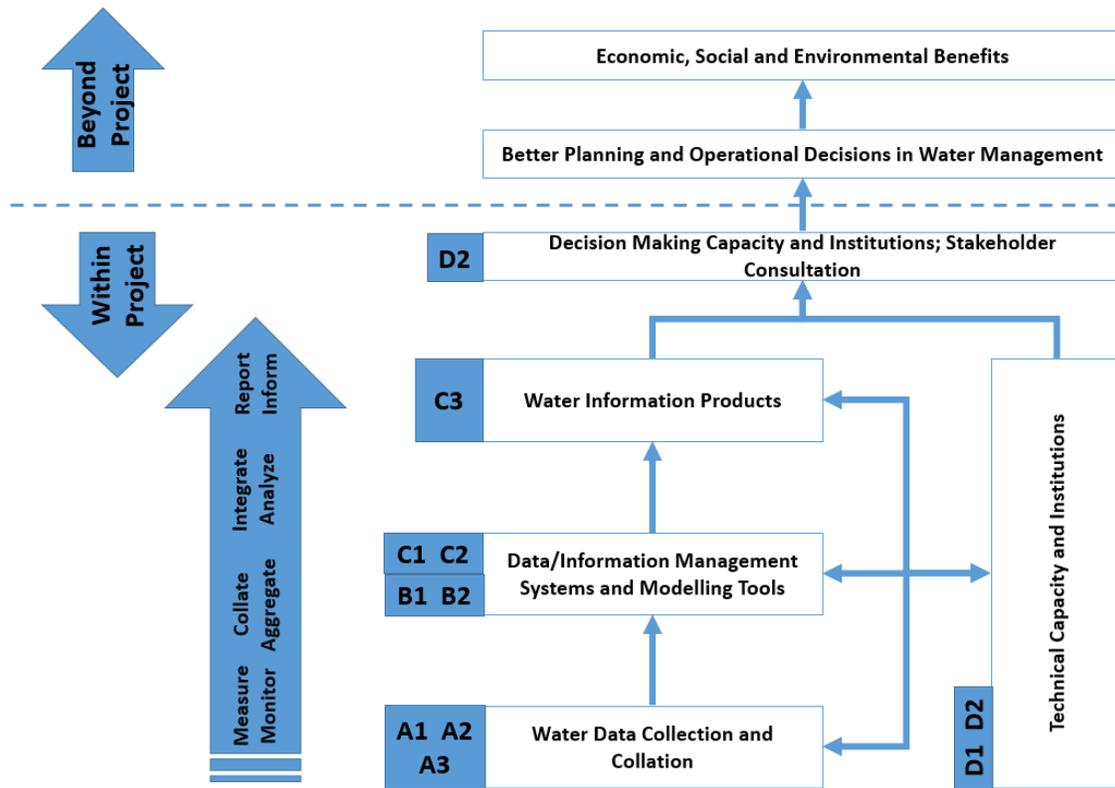


Figure 1.1: Conceptual framing of the Project, showing components/sub-components.

#### 1.4.4 Component A: Water Resources Data Acquisition System (WRDAS) – USD 147 Million

23. This foundational component will be implemented by all state and core central agencies and will focus on improving the extent and reliability of water resources data for improved water resources assessment, reservoir operation, flood, and groundwater management. The reliability of data will be ensured through digitation/automation with telemetry and GPS-time stamped monitoring in case of manual data. The major activities would include:

- i. **Water Resources data acquisition network** will be upgraded or newly established to measure weather parameters; water availability, use and water quality in river, reservoir (or other water bodies), canal, and groundwater; Supervisory control and data acquisition (SCADA) system for reservoirs and canal network to improve the reliability and efficiency of operational water management. In addition, physical measurements will be supported to determine site specific characteristics including river cross-section, discharge, morphology, sedimentation and aquifer characteristics.
- ii. **Establishment of Hydro-informatics centers:** State and national water data centers will be upgraded or established for automated data collection, collation and processing, centralized hubs for operational control systems, and water quality analysis laboratories. The project will also support the modernized infra-structures and establishment of Hydrological instrument facility, cloud and physical servers.

24. The component will support civil works for infrastructure development and for establishment of hydromet sites, procurement of software/servers; good and services for hydromet, IT equipment and Water quality equipment. A centralized framework rate contract will be established for hydro-met systems, telemetry services, and integrators to facilitate the procurement by all agencies.

#### 1.4.5 Component B: Water Resources Information System - USD 48 Million

25. The objective of this component is to standardize, integrate and improve the accessibility of data, information and products through online products and web-portals for public and Government to Government (G to G). In particular, the aim is to improve the communication and exchange between G-to-G (state government and central government) and facilitate real-time operation and decision making at river basin scale. The major activities would include:

- i. **Standardized Database management:** During HP-II, web-based standardized database management system (data entry, validation and storage) were developed for surface water (e-SWIS), Groundwater (e-GEMS) and water quality (e-WQIS) to minimize operation and maintenance burden on states. These will be further improved and rolled out for the entire country to enable the standardization and collation of database at National /River Basin scale.
- ii. **Web-based WRIS at National and sub-national levels:** Web-based National Water Resources Information System (NWRIS) (IndiaWRIS) has already been developed during HP-II by CWC and is available with spatial-temporal database to public. It will be further strengthened and populated to serve various stakeholders. The National level (NWRIS) will aim at integrating and standardizing the river basin data and providing national scenario/assessment for policy framework while replica at sub-national (river basin or SWRIS) will support decisions in various disciplines/departments for operation, planning and management. The SWRIS will be customized for states, including copies in regional languages.
- iii. **Development of Information products:** Given the lack of metering of water use, alternative approaches such as earth observation products and/or remote sensing based techniques will be introduced. The project will support the use of earth observation data to improve assessment of evapotranspiration (ET), precipitation, river morphology, improve digital elevation models, and other weather parameters and forecast. In addition, real time products will be introduced such as weather forecast, ET estimates and water availability in river/reservoirs.

#### 1.4.6 Component C: Water Resources Operation and Planning systems– USD 56 Million

26. The objective of this component is to build on the information systems of Component B by developing and deploying modeling and decision support tools, and by using the combination of information systems and modeling tools to generate water information knowledge products that inform improved water resources operations and planning. A large component of this work will be the procurement of consultancies by CWC for model development for floods and water resources assessments in large river basins and states will develop decision support systems for operation and water allocation planning. This component will support development of analytical tools and DSS for:

- i. **Water Resources modelling tools and DSS** for river basin water resources assessment, water accounting, basin systems simulation, optimization, and multi-criteria models to analyze various systems.
- ii. **Flood forecasting and reservoir operation systems to manage** floods and improve lead time by integrating with climate forecast. The forecasting tools will include weather forecast ranging from seasonal forecasting to now-casting; and short and medium-term forecasts;

stream flows, and mapping of flood inundation. Based on the streamflow forecasting in major rivers by CWC, states will operationalize real-time reservoir operation systems.

- iii. **DSS for Irrigation operation and management** will schedule releases from reservoir and canals based on crop demand and phenology, benchmark irrigation system to improve irrigation efficiency based on remotes sensing based information and water use monitored in Component A. Support will be provided to strengthen promising WALMIs to benchmark irrigation system as well as to promote and facilitate the communities' participation in water management. In addition, conjunctive water management will be introduced.
- iv. **Knowledge Generation and Management** will build on the experience in previous phases of the Hydrology Project to provide support for purpose driven studies (PDS) and the further development of Hydrologic Design Aids (HDA) that use data and analytical tools to fill critical water resources knowledge gaps. The PDS program is expected to include studies covering a wide range of water management issues, both surface water and groundwater, including water quality studies, conjunctive use studies, sedimentation studies and the like.

27. This component will also support development of publications and interactive products and services to improve communication to stakeholders. Knowledge portals will provide easy access to documentation and online mapping, offer training, support social-media networking, and help visualize complex information. Support will also be provided for secure within-government portals operational water resources information at national and state level.

#### **1.4.7 Component D: Institutional Capacity Enhancement – USD 83 Million**

28. The objective of Component D is to build the capacity and capability for both the technical and planning dimensions of water resources management. Increased professional capacity and stronger institutions are vital, together with improved water resources information, to enable improved decision making in water resources operations and planning. This component will support:

- i. **Water Resources Knowledge Centers:** The development of existing centers of relevant expertise and the development of new centers will be used to focus on development of expertise in (i) an India Water Resources Knowledge Centre, (ii) sub-national centers and (iii) special centers (flood, groundwater modeling). These will be supported through construction of buildings to house the center (where needed), equipping the center and providing resources for staffing of high caliber staff to work on the project (such as through the PDS program or flood/water resource modeling)
- ii. **Professional Development:** Training support will be a focus activity in this project through a wide variety of means, opportunities and coordinated programs - including classroom, online and exchange programs. Collaboration with national and international institutes to broaden the horizons of training programs will be an important activity in order to proliferate hydrologists and water managers across the country.
- iii. **Project Management:** Support for project implementation through consultancies for technical and administrative skills and resources, management information systems and financial reporting systems to provide resources for the challenge of coordination and driving effective project implementation.

29. This component will also provide support for effective management and facilitation of the activities and will include support at national and sub-national levels for technical assistance, activity management, procurement, financial management, safeguards, training, communication, monitoring, learning, evaluation, and adaptive management. This sub-component will include support for: (i) a central project management unit, (ii) state project management units, (iii) technical quality control for hydro-met equipment, (iv) monitoring and evaluation, and (v) governance and accountability.

## 1.5 Institutional and Implementation Arrangements

30. NHP is a centrally funded project and will be implemented by Ministry of Water Resources, River Development and Ganga Rejuvenation and the implementation structure will be fine-tuned based on the experience of Hydrology Project Phase II. The project will have three tier structure for policy, management and coordination and will ensure data integration of multi-sector and river basin approach. The project implementation responsibilities will be decentralized through the respective central agencies and state organizations participating in the project. While MoWR, RD&GR will assume the lead role in overall coordination and implementation of the project, each implementing agency will be responsible for implementation of its part of activities for the project implementation and will be accountable for the expected deliverables.

31. *At the central level* the National Level Steering Committee (NLSC) will be the apex body overseeing project implementation with administrative, management and coordination roles. The NLSC will be supported by *National Project Management Unit (NPMU)* consisting of core staff from MoWR, RD&GR and supported by a technical and management Consultant Team. The NPMU will be responsible for program management, monitoring and reporting, development and maintenance of MIS, financial management, procurement management, change management and communication and outreach activities.

32. *Coordinating Agencies* at the national level have been identified for each of the project components, which will constitute various technical committees to assist implementation.

**Table 1.2. Component wise Coordination**

Component	Main Function	Responsible Institution
A1	Design of Hydromet and Procurement	CWC, CGWB, CPCB
A2	R&D for hydromet	CWPRS
B1	Standard database management systems	CWC, CGWB, CWPRS
B 2	NWRIS standards and protocols	NWIC, CWC
B 2	Data sharing protocols and monitoring	NPMU
C 1,2	Flood forecasting and River basin assessment models	CWC
C 1,2	River basin modelling training and expert support	NIH
C 3	Scope of PDS and technical support	NIH
D 1	Collaborations with International organizations	NPMU
D 2	National and international trainings	NIH
D 3	Overall Project Management, M&E and FM	NPMU

33. *At the state level* the implementing agencies will be state water resources (irrigation) department and/or groundwater department. Some states have joint surface and ground departments while some have separate departments. State Level Steering Committee chaired by Principle Secretary in charge of Water resources will coordinate for both the departments.

## 1.6 Results Monitoring and Evaluation

34. A key focus for the project is institutionalization of hydro-met information systems. The tools through which this can be achieved are MIS and web-based monitoring of project implementation, sensitization and communication to all stakeholders on use of knowledge-based tools and products, and the building a

learning environment for implementing agencies. A web-based MIS to track progress and performance of implementing agencies will be central to the project M&E framework. Introducing applications for mobile devices will bring all agencies into a participatory monitoring process. In addition to regional and national learning fora to be organized periodically, the project will facilitate frequent webinars and virtual learning and sharing events.

35. The key indicators for measuring project success have been identified and are provided in Annexure 1. Monitoring of implementation progress include monitoring each implementing agency, frequent data auditing and supportive supervisions. The project will introduce innovative monitoring tools including thematic studies, performance assessments, mapping and audits. Monitoring would use HP-II achievements as a baseline and conduct evaluations at mid-term and project closure. The mid-term evaluation would guide performance-based budget allocations to the implementing agencies.

## **2 CHAPTER 2: ENVIRONMENTAL ISSUES IN THE PROJECT**

### **2.1 No adverse impacts from the Project**

37. The Project will cover all States of India and will draw lessons of the National Hydrology Projects Phase I and II implemented in the Southern Peninsular States, Himachal Pradesh and Punjab.

38. Components 2 and 4 are not expected to have any environmental and social impacts. Component 3 (preparation of sub-basin level plans for water resources management or for drought management) may have environmental and social consequences, which need to be managed. It is therefore, important to have a robust process of sub-basin plan preparation which takes care of the potential social and environmental risks. Almost all states lack adequate and appropriate capacity to manage the process of preparation of basin or sub-basin plans, and the project will support building that capacity. As part of the capacity building component for the implementing agencies, the component 4 will also build/augment capacity to review and supervise the process of preparation sub-basin plans, and the process to ensure that the potential environmental and social are identified adequately, avoided or addressed adequately.

39. In fact, the project interventions and outcomes will contribute to better overall sustainable environmental management in India, and as such be considered as part of the overall national capacity building for environmental management. By (i) setting in operation a reliable and accessible hydrological knowledge base of meteorology, surface and ground water resources and water quality; and by (ii) promotion of use of hydrological models and analytical tools.

### **2.2 World Bank's Safeguards Policies**

#### **2.2.1 Environmental Assessment OP/BP 4.01**

40. The project components 2 and 4 do not have any environmental impacts. Component 1 which will set up monitoring stations, and associated facilities and infrastructure that may have small footprints, and very low levels of environmental impacts. Component 3 (preparation of flood and drought management support system, or water resources management) may have impacts when recommendations are implemented, and therefore, it is important to prepare these system in a manner and through a process that identify all relevant environmental issues, avoids generation of those issues, and mitigates and manages these issues as part of the planning process. This will be taken care by mainstreaming environmental management issues in the terms of reference of the basin or sub-basin level plans for water resources management or flood management or drought management (and referred to in the operational manual of the project).

#### **2.2.2 Natural Habitats OP/BP 4.04**

41. No direct or indirect impact on natural habitats. Any potential indirect impact will be avoided or mitigated as part of the process of preparation of the sub-basin plans (i.e., during implementation of component).

#### **2.2.3 Forests OP/BP 4.36**

42. No direct or indirect impact on forests or livelihood based on forests. Any potential indirect impact will be avoided or mitigated as part of the process of preparation of the sub-basin plans (i.e., during implementation of component).

#### 2.2.4 Pest Management OP 4.09

43. The project does not finance any chemical or synthetic pesticide. In fact rational and balanced use of pesticide, avoidance of WHO Classes 1 and 2 pesticides, and adoption of IPM and NPM will expected to be promoted by the sub-basin level water resources arrangement plans.

#### 2.2.5 Physical Cultural Resources OP/BP 4.11

44. No direct or indirect impact on forests or livelihood based on forests. Any potential indirect impact will be avoided or mitigated as part of the process of preparation of the sub-basin plans (i.e., during implementation of component.

#### 2.2.6 Indigenous Peoples OP/BP 4.10

45. The Project when implemented in Scheduled Areas 5 and 6 and covered by Forest Rights Act, 2006 will not trigger this OP/BP as forest and/or any land on which the Scheduled Tribes depend to meet their social, economic and cultural needs will be used for the Project. However, they will enjoy the benefits of Community Based Water Resource Management program, if required to be implemented in Scheduled Areas. When this is required, it will be prepared as an outcome of free, prior and informed process of consultations with them.

#### 2.2.7 Involuntary Resettlement OP/BP 4.12

46. OP/BP on Involuntary Resettlement will not be triggered as the Project will not require any Private *Patta* (titled) land or any other land under any Government tenure systems causing adverse impacts for its civil works. Civil works, where required, will be on existing land belonging to States and or Departments that are free of any encumbrances on within existing campuses or as addition to existing buildings.

#### 2.2.8 Safety of Dams OP/BP 4.37

47. The project will finance data and analytical tools. The reservoir operation system may suggest improvement of operating rules for some reservoirs (that will be selected depending on the success of components 1 and 2 during implementation). The project will examine the need for specific examination of all such dams, and as required will (i) accept selection of the dams where the borrower's dam safety review and management processes are deemed to be adequate and appropriate, for consequent preparation of reservoir operation plans; or in the event when the borrower's dam safety review and management were not found to be adequate and effective, (a) hire services of an independent panel of experts on dam safety; and/or (b) implement the requisite inspection, remedy or any other dam safety measure. These mechanisms will be covered by the operation manual of the project.

#### 2.2.9 Projects on International Waterways OP/BP 7.50

48. The project does not finance any intervention, or any detailed design and engineering study that triggers the policy. The relevance and application of the Policy will be assessed during preparation, and will be updated, as necessary at appraisal.

#### 2.2.10 Projects in Disputed Areas OP/BP 7.60

49. There is no known locations of the project's footprint is in the disputed areas.

### **2.3 Rationale for Undertaking the Environment Assessment**

The project interventions and outcomes will contribute to better overall sustainable environmental management in India, and as such be considered as part of the overall national capacity building for

environmental management. By (i) setting in operation a reliable and accessible hydrological knowledge base of meteorology, surface and ground water resources and water quality; and by (ii) promotion of use of hydrological models and analytical tools. Any potential indirect and/or long term impacts due to anticipated future activities in the project area will only be beneficial to small and marginal farmers, those who depend on water resources for their livelihood and also those who live along the rivers/river basins including women, Scheduled Tribes and other vulnerable sections of the community. The benefits includes, among others, access to irrigation, drinking and floods management.

50. The project components 2 and 4 do not have any environmental impacts. Component 1 which will set up monitoring stations, and associated facilities and infrastructure that may have small footprints, and very low levels of environmental impacts. Component 3 (preparation of flood and drought management support system, or water resources management) may have impacts when recommendations are implemented, and therefore, it is important to prepare these system in a manner and through a process that identify all relevant environmental issues, avoids generation of those issues, and mitigates and manages these issues as part of the planning process. This will be taken care by mainstreaming environmental management issues in the terms of reference of the basin or sub-basin level plans for water resources management or flood management or drought management (and referred to in the operational manual of the project).

51. This environmental assessment is carried out therefore to augment the plan of water quality monitoring (which is part of the project, anyway). In specific, this environmental assessment ensured discussion and agreement among all agencies in India working on water quality (by bringing them at one platform, and by agreeing with a set of common minimum sets of procedures related to monitoring mechanisms).

52. Similarly, the project anyway will support preparation of basin plans (by providing important inputs, even if the project may not finance preparation and finalization of basin plans). This environmental assessment is undertaken to ensure that important environmental issues – such as water quality and ecological flows – are mainstreamed in the preparation of basin plans (by making these issues prominent in the terms of reference for preparation of the basin plans).

53. In that sense, this environmental assessment is not aimed at mitigation of any negative impacts of the project. **This environmental assessment, in fact, is aimed only at enhancement** of the design, outcome and results of the project.

## **3 CHAPTER 3: WATER QUALITY ISSUES & INTERVENTIONS**

### **3.1 Availability of Water Resources**

54. The availability and the quality of the fresh water resources is the most pressing of the many environmental challenges on the national horizon in India. The stress on water resources is from multiple sources and the impacts can take diverse forms. Geometric increase in population coupled with rapid urbanization, industrialization and agricultural development has resulted in high impact on quality and quantity of water in India. The urban population has increased almost 11 fold in last 100 year period from 26 million to 285 million. Unregulated growth of urban areas, particularly over the last two decades, without infrastructural services for proper collection, transportation, treatment and disposal of domestic wastes led to increased pollution & health hazards. The municipalities and such other civic authorities have not been able to cope up with this massive task which could be due to various reasons including erosion of authority, inability to raise revenues and inadequate managerial capabilities. That is why it became necessary to launch the Ganga Action Plan and subsequently the National River Action Plan, which is essentially addressed to the task of trapping, diversion and treatment of municipal waste water. The situation warrants immediate redress through radically improved water resource and water quality management strategies.

55. Depletion of available freshwater resources, falling ground water levels and deteriorating water quality are all posing a variety of challenges in managing India's water resources. Competing demands from the needs of a growing population are quite often leading towards disputes among users. The per capita water availability in India is raising concerns. By the increase in population by the end of 21<sup>st</sup> century, the per capita availability is likely to drop below 1000 cubic meters a situation labeled as water scarcity.

56. From the East to the West and from the North to the South, water has defined life in the Indian subcontinent for thousands of years. On an average, the combination of rainfall, surface and groundwater resources have been sufficient in providing adequate water to the Indian population. Rise in demand and development pressures are changing the characteristics of water in India. Erosion in the watershed due to the fast growing development and poor land management practices is changing stream hydraulics.

57. Groundwater reserves are becoming more and more depleted as surface water sources have become too polluted for human use. Water security is emerging as an increasingly important and vital issue for India. Many Indian cities are beginning to experience moderate to severe water shortages, brought on by the effects of agricultural growth, industrialization and urbanization. Population stress, irrigation requirements and industrialization are the major pressures for water insecurity.

58. The environmental challenges of water resource development and management in India are expected to manifest themselves more rapidly in the coming years. These environmental challenges may be addressed through four broad approaches:

- i. Improving efficiencies and minimizing losses;
- ii. Recharging groundwater aquifers;
- iii. Abatement and treatment of water pollution; and,
- iv. Reuse and recycling of wastewater.

### **3.2 Current and Future Water Requirements**

59. In 1990, the total water withdrawal was estimated at 552 bcm i.e. 30 per cent of the country's renewable water resources. The contribution from surface water was 362 bcm, while the groundwater withdrawal was estimated at 190 bcm. Approximately 460 bcm was used for irrigation while 25 bcm was used for domestic needs. About 19 bcm and 15 bcm were used for energy and industrial purposes respectively. Currently, more than 80 per cent of the 750 bcm water used in India is for irrigation. The balance 20 per cent is used

to meet domestic, energy, industrial and other requirements. With the rapidly growing population, along with industrial and urbanization activities, the demand for water is expected to increase even faster. Estimates indicate that by the year 2025, the total water demand of 1050 bcm will be very close to the total utilizable water resources of 1,122 bcm in the country. Though projections are not available beyond 2025, it is evident that the country may have to face an acute water crisis unless clear and strategic measures are adopted now. It is important to note that more attention is also required to scientifically assess the water requirements for ecosystems security. Today, approximately 40 per cent (748 bcm) of available water resources is considered to be unutilizable due to a variety of factors. Probably, this is a blessing since that water must be used for the requirements of the ecosystems.

### **3.3 Water Pollution**

60. The key challenges to better management of the water quality in India are temporal and spatial variation of rainfall, uneven geographic distribution of surface water resources, persistent droughts, overuse of ground water and contamination, drainage & salinisation and water quality problems due to treated, partially treated and untreated wastewater from urban settlements, industrial establishments and runoff from irrigation sector besides poor management of municipal solid waste and animal dung in rural areas.

61. It is estimated that about 38,000 million litres per day (mld) of wastewater are generated in the urban centres having population more than 50,000 in India (housing more than 70% of urban population). The municipal wastewater treatment capacity developed so far in India is about 11,000 mld accounting for 29% of wastewater generation in these two classes of urban centers. In view of population increase, demand of freshwater for all the uses will be unmanageable. It is estimated that the projected wastewater from urban centres may cross 1,00,000 mld by 2050 and the rural India will also generate not less than 50,000 mld in view of water supply designs for community supplies in rural areas. However, waste water management is not addresses to that pace.

62. Most human activities whether domestic, agricultural or industrial have an impact on water and the ecosystems. Water borne diseases can be, to a large extent, controlled by managing human consumption and production patterns. It is therefore important to have an understanding of human activities, including water management initiatives, and their impacts on water and the environment.

#### **3.3.1 Domestic Water Pollution**

63. Waste management systems have not been able to keep pace with the huge volumes of organic and non-biodegradable wastes generated daily. As a consequence, garbage in most parts of India is unscientifically disposed and ultimately leads to increase in the pollutant load of surface and groundwater courses. On the other hand, the large population of the poor in India does not have much choice but to live off the natural resource base and pollute the environment in the process. They deforest for food, fuel, fodder and fibre and pollute the water sources on which they depend, since they cannot afford access to sanitation services.

64. Domestic water use today, though a small fraction of the total water requirement, is underpriced for political reasons. This leads to a considerable waste of the precious resource and inadequate revenues for operation and maintenance. Low revenues result in the loss of the resource due to system inefficiencies. In most parts of the country, waste water from domestic sources is hardly treated, due to inadequate sanitation facilities. This waste water, containing highly organic pollutant load, finds its way into surface and groundwater courses, very often close to dense pockets of human habitation from where further water is drawn for use. Considerable investments will be required to install treatment systems in at least the 500 major cities and towns of the country. Estimates indicate that it is viable to set up decentralized treatment systems for approximately 100 to 200 households where it is possible to convince users to pay for efficient services. Incentives like soft loans may be provided to these initiatives.

### 3.3.2 Industrial Water Pollution

65. The Industrial sector, contributing to about 20 per cent of the national income, accounts for about 8 per cent of the current water use. With rapid industrialization and urbanization, the water requirement for energy and industrial use is estimated to rise to about 18 per cent of the total requirements in 2025. Poor environmental management systems, especially in industries such as thermal power stations, chemicals, metals and minerals, leather processing and sugar mills, have led to discharge of highly toxic and organic wastewater. This has resulted in pollution of the surface and groundwater sources from which water is also drawn for irrigation and domestic use. The enforcement of regulations regarding discharge of industrial wastewater and limits to extraction of groundwater needs to be considerably strengthened, while more incentives are required for promoting waste water reuse and recycling.

### 3.3.3 Agricultural Water Pollution

66. Two-thirds of India's farm production comes from one-third of its land which is irrigated. The rest is from rain-fed areas that employ large populations. In order to meet the increasing demand for food and farm employment, India has to increase the area under irrigation, and enhance productivity in both irrigated and rain-fed areas. Cropping patterns and farming practices also do not encourage the judicious use of water. Conservative estimates indicate that the same quantity of irrigation water used today can irrigate double the current area with optimized irrigation and farming practices. With limited revenues and budgetary support, the state engineering departments are unable to operate and maintain the irrigation systems efficiently, leading to increasing deterioration of the structures and systems over time.

67. Consequently, there are further water losses due to breaches and seepage, resulting in water logging and salinity. Water quality is further affected due to the overuse of chemical fertilizers and pesticides.

## 3.4 **Legal framework for Water Quality Management**

### 3.4.1 Water Act, 1974

68. The Water Act of 1974 is an Act to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water, for the establishment, with a view to carrying out these purposes the state and central pollution boards for the prevention and control of water pollution were established. It defined various types of pollutions, constitution of the state and central boards for prevention and control of water pollution.

69. "Water" being a "state subject", the Parliament can exercise the power to legislate on "water" under certain articles of the Constitution of India. Resolutions were passed by all Houses of the Legislatures of the States of Assam, Bihar, Madhya Pradesh, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Rajasthan, Tripura and West Bengal to the effect that the matters relating to prevention and control of water pollution should be regulated by the Parliament by law. Accordingly the Parliament enacted the Water (Prevention and Control of Pollution) Act, 1974. The Water Act represents one of India's first attempts to deal with an environmental issue comprehensively. The Water Act was first amended in 1978. It was again amended in 1988 to conform to the provisions of the Environment (Protection) Act, 1986. The main aim and object of the Act of 1974 is 'to maintain or restore the wholesomeness of water and to prevent, control and abate water pollution'. To achieve these objectives, the Act has provided various chapters which are very comprehensive. In view of this Act, the fundamental objective of the statute is to provide clean water to citizens. The definition of water pollution in the act is a very comprehensive definition and covers all the changes in physical, chemical or biological properties of water. The definition also covers the rise in the temperature of water and discharge of radioactive substances in the water. The Act has used two terms in relation to water pollution- stream and well. The 'stream' here includes (a) river, (b) water courses (whether flowing or for the time being dry), (c) inland water (whether natural or artificial), (d) subterranean water (underground water), (e) Sea or tidal water.

### 3.4.2 Environment Protection Act

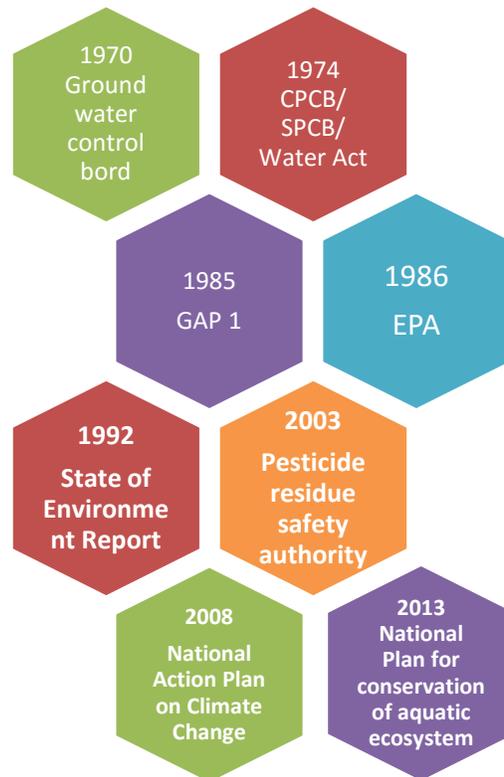
70. **Environment Protection Act, 1986** is an Act of the Parliament of India. In the wake of the Bhopal Tragedy, the Government of India enacted the Environment Protection Act of 1986 under Article 253 of the Constitution. Passed in March 1986, it came into force on 19th November 1986. The purpose of the Act is to implement the decisions of the United Nations Conference on the Human Environment they relate to the protection and improvement of the human environment and the prevention of hazards to human beings, other living creatures, plants and property. The Act is an “umbrella” legislation designed to provide a framework for central government coordination of the activities of various central and state authorities established under previous laws, such as the Water Act and the Air Act.

71. Objectives of the Act include:

- To co-ordinate the activities of the various regulatory agencies already in existence.
- Creation of an authority or authorities with adequate powers for environmental protection.
- Regulation of discharge of environmental pollutants and handling of hazardous substance.
- Speedy response in the event of accidents threatening environment and punishment to those who endanger human environment, safety and health

72. Under the Environment Protection Act, regulations and standards for water quality were set up.

**Figure 3.1: Land marks in Indian Governance regarding water quality issues**



## 3.5 Water Quality Management Programs (Past, current and future outlooks)

### 3.5.1 National river conservation program

73. Launched in 1993 and was envisaged to carry on till 2007 The National River Conservation Directorate (NRCD) in the Ministry of Environment, Forests and Climate Change is implementing the Centrally Sponsored Schemes of National River Conservation Plan (NRCP) and National Plan for Conservation of Aquatic Eco-systems' (NPCA) for conservation of rivers, lakes and wetlands in the country.

74. The objective of the River Action Plans is to improve water quality of rivers through implementation of pollution abatement schemes in identified polluted stretches of rivers. NPCA aims at conserving aquatic ecosystems (lakes and wetlands) through implementation of sustainable conservation plans, and governed with application of uniform policy and guidelines. Out of the total measurable pollution in the rivers from various point sources, around 75% is contributed by municipal sewage from towns located along the banks of rivers and remaining 25% by industrial effluents.

- i. **Point sources:** These are organized sources of pollution where the pollution load can be measured, e.g. surface drains carrying municipal sewage or industrial effluents, sewage pumping stations and sewerage systems, trade effluents from industries, etc. Pollution loads due to untreated sewage is one of the main reasons threatening the ecological health of rivers. Most of the urban lakes in the country are also facing similar challenges.
- ii. **Non-point sources:** These are non-measurable sources of pollution such as run-off from agricultural fields carrying chemicals and fertilizers, run-off from solid waste dumps and areas used for open defecation, dumping of un-burnt/half-burnt dead bodies and animal carcasses, dhobi ghats, cattle wallowing, etc.

75. **Magnitude of the problem:** The pollution loads in rivers & lakes have been increasing over the years due to rapid urbanization, industrialization and drastic increase in population. Extraction of water for irrigation, industrial, drinking purposes etc., is compounding the problem.

76. As per the CPCB Report of 2009-10, the estimated sewage generation from Class-I & Class-II towns in the country was around 38,255 mld (million litres per day), whereas corresponding sewage treatment capacity available was only 11,787 mld, or 30% of the sewage generation. As per the recent study (2014-15) carried out by CPCB, the sewage generation from urban areas is estimated at around 57,233 mld. Against this, 682 STPs having a total treatment capacity of 21,478.69 mld were available (37% of the sewage generation). It may be noted that in addition to the installed capacity, 217 STPs with a treatment capacity of 3099.73 mld were under construction/proposed for construction. Thus, it can be seen that while the installed treatment capacity has nearly doubled over the last 5–7 years, the high urbanization and increase in urban population has led to increase in gap between sewage generation and treatment capacity available

77. The Biochemical Oxygen Demand (BOD) is the key pollution indicator for rivers and lakes. Based on water quality monitoring done on regular basis, polluted stretches have been reported by CPCB from time to time. In their last report of 2015, 302 polluted river stretches have been identified out of which pollution abatement works in some of the stretches have been taken up under NRCP.

78. The river conservation program in the country was initiated with the launching of the Ganga Action Plan (GAP) in 1985. The Ganga Action Plan was expanded to cover other rivers under National River Conservation Plan (NRCP) in the year 1995. NRCP, excluding the GAP-I, GAP-II and National Ganga River Basin Authority (NGRBA) program presently covers polluted stretches of 40 rivers in 121 towns spread over 19 States at a sanctioned cost of Rs.5779.41 crore. 40 rivers have been included in this plan.

79. The pollution abatement works are implemented on a cost sharing basis between the Centre and State Governments. The works include; collection, transportation and treatment of municipal sewage, River Front Development (RFD), Low Cost Sanitation (LCS), Electric Crematoria, Improved Wood Based Crematoria etc. So far, sewage treatment capacity of 3729 mld (million litres per day) has been created under NRCP, excluding GAP-I, GAP-II and NGRBA. Prevention and control of industrial pollution is being addressed by the Central and State Pollution Control Boards/Pollution Control Committees.

### 3.5.2 Ganga Action Plan; Namami Ganga; and other programs on the Ganga

80. Ganga Action Plan Phase 1 & 2: At the time of launching the main objective of GAP was to improve the quality of water of Ganga to acceptable standards by preventing the pollution load reaching the river. However, was subsequently decided that the objective of the GAP was recast as restoring the river quality to the 'bathing class' standard.

81. Ganga Action Plan (GAP) Phase-I was launched in the year 1985 to improve the water quality of river Ganga and was completed in March 2000. Phase-II of the program was approved in stages from 1993 onwards which included tributaries of the river Ganga namely, Yamuna, Gomti, Damodar and Mahananda. Pollution abatement works undertaken include, interception and diversion of raw sewage, setting up of sewage treatment plants, creation of low cost sanitation facilities, setting up of electric/improved wood crematoria and river front development. GAP Phase-II is currently under implementation. An expenditure of Rs. 896.05 crore has been incurred so far on Ganga under GAP and sewage treatment capacity of 1064 million litres per day) has been created.

82. A project under the National Ganga River Basin Authority (NGRBA) with World Bank assistance for abatement of pollution of river Ganga at an estimated cost of Rs.7000 crore has been approved in April 2011 by the Central Government. The World Bank will provide financial assistance of US \$ 1 billion. The principal objective of the project is to fund creation of pollution abatement infrastructure for conservation and restoration of water quality of the river. The assistance would be in form of a loan of \$801 million from International Bank for Reconstruction and Development (IBRD) and a credit of \$199 million from International Development Association (IDA).

83. The Project will focus on building and strengthening the institutional framework at the Central and state level; establishing a Ganga Knowledge Centre; enhancing river basin management; and financing priority investments for pollution abatement in a sustainable manner. Project implementation will be in accordance with a Program Framework, developed by the Centre and States for NGRBA which includes implementation arrangements, criteria for selection of investments, Procurement Manual, Financial Manual, an Environment and Social Management Framework, etc. The Ganga Action Plan or GAP was a program launched in January 1986 to reduce the pollution load on the river. But the efforts to decrease the pollution level in the river were unsuccessful even after spending INR 9017 million. Therefore, this plan was withdrawn on 31 March 2000. The steering Committee of the National River Conservation Authority reviewed the progress of the GAP and necessary correction on the basis of lessons learned and experiences gained from the GAP; phase 2 schemes have been completed under this plan. A million litres of sewage is targeted to be intercepted, diverted and treated. Phase 2 of the program was approved in stages from 1993 onward and included the following tributaries of the Ganges: Yamuna, Gomti, Damodar and Mahananda. As of 2011, it is under implementation.

84. In the budget tabled in Parliament on 10 July 2014, the Union Finance Minister Arun Jaitley announced an integrated Ganga development project titled 'Namami Ganga' (meaning 'Obeisance to the Ganga river') and allocated INR 2,037 crore for this purpose. As a part of the program, government of India ordered the shutdown of 48 industrial units around Ganga.

85. Problem Areas under Ganga Action Plans: With the completion of the Ganga Action Plan Phase I, bottlenecks have appeared in respect of operation and maintenance (O&M) of the assets created under the program. Expenditure towards operation and maintenance of facilities like sewage treatment plants and

main sewage pumping stations under Ganga Action Plan Phase-I was fully met by the Centre up to September, 1989 and thereafter was shared equally with the respective State Governments from October, 1989 onwards till March, 1997. As decided during the initial periods of GAP, the responsibility of O&M of assets created under the GAP thereafter rested with the concerned State Governments. While O&M of assets is unsatisfactory in Bihar and to some extent in UP, O&M of major assets in West Bengal is generally satisfactory. U.P. and Bihar have not been able to provide uninterrupted electricity for running the facilities.

86. Electric crematoria are reported to be running satisfactorily in West Bengal only. But in Bihar and U.P., O&M of these assets is not satisfactory. A total of 128 bathing ghats have been constructed and most of them are not being maintained properly. Now the Ministry approves only those projects where State Governments give firm commitment for operation and maintenance of assets created under the scheme. Emphasis on appropriate technologies aimed at reducing these pollutants is being increasingly given under GAP-II.

87. Out of the total sewage generation of 1,340 mld from 25 class I towns (as of 1985), it was targeted to intercept, divert and treat 873 mld of sewage under GAP Phase-I. As against this target, capacity to treat 865 mld has been commissioned so far.

88. The water quality of river Ganga is being monitored at 27 locations from Rishikesh in Uttaranchal to Uluberia in West Bengal by reputed academic institutions such as Bharat Heavy Electrical Limited (BHEL), Haridwar, CPCB Zonal Office, Indian Institute of Technology, Kanpur, Patna University and Bidhan Chandra Krishi Vishwavidyalaya, Kalyani. As a result of the schemes completed under GAP Phase-I, the water quality of river Ganga for the year 2002 shows improvement in respect of the Biochemical Oxygen Demand (BOD) which is a major indicator of pollution. The summer average values of two important river water quality parameter viz. Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) for some of the important monitoring stations on river Ganga is given in Table-13. It has been observed that the BOD in the critical stretches of Kanauj to Varanasi which was in the range of 5.5 to 15.5 mg/l has now been reduced to 1.2 to 4.90 mg/l. Monitoring of rivers under GAP-II namely Yamuna, Western Yamuna Canal, Gomti and Hindon is continuing. Rivers of NRCP are being included in the water quality monitoring program as and when the core schemes for the towns on that river are sanctioned. Performance monitoring of sewage treatment plants wherever commissioned and operational is an integral part of Water Quality Monitoring.

89. Water Quality Monitoring has also been initiated for the rivers vis. Sutlaj in Punjab, and Tungahadra in Karnataka and Cauvery in Tamil Nadu. Suitable institutions for undertaking water quality monitoring in other rivers covered under NRCP have been identified and the process of monitoring is being taken up for towns where core schemes have been approved. All the participating laboratories involved in water quality monitoring have been subjected to Analytical Quality Control (AQC) by the CPCB. The institutes/universities carrying out water quality monitoring have been entrusted with the additional responsibility of evaluating the performance of the sewage treatment plants set up

### 3.5.3 Yamuna Action Plan

90. Originally, Yamuna Action Plan covered pollution abatement works in 15 towns, break-up being Haryana (six), U.P. (eight) and one in Delhi. In April 1996, on the directions of the Supreme Court, six additional towns of Haryana were included under YAP. Works in these towns are implemented through the Plan funds of the Ministry. Thus, YAP presently covers pollution abatement works in 21 towns. The approved cost of YAP is Rs. 509.45 crore of which an expenditure of Rs. 462.69 crore has been incurred so far. A treatment capacity of 724 million litres per day has been created. Together with this additional package, the total cost of Yamuna Action Plan stands at Rs. 732.05 crore.

91. In order to address further problem of water pollution of river Yamuna, additional pollution abatement works in the State of Delhi, Haryana and U.P. have been posed for funding by JBIC under Yamuna Action Plan Phase-II. The total cost of project is estimated at Rs. 637 crore for which loan agreement with Govt.

of Japan is expected to be signed in February, 2003 and works scheduled to start in April, 2003 with a completion period of five years.

92. In addition to the Yamuna Action Plan of the Ministry, the Government of NCT of Delhi has also taken up large scale sewerage and sewage treatment plant works out of its own plan funds. The quality of river Yamuna is being monitored by the Supreme Court. The Court has issued directions to the Government of NCT of Delhi to complete all the works by 31<sup>st</sup> March, 2003. The ongoing second phase of YAP was started in December 2004 with an approved cost of Rs.624crore with a completion period of 5 years. Starting of this phase took some time due to compliance to the administrative and procedural requirements. Excess sanctioned cost is due to revision in scope of works, taking up of additional works etc. which are borne by the respective State Governments. A total sewage treatment capacity of 767.25 million litres per day (mld) has been created under both the phases.

93. Other pollution abatement works undertaken include, creation of community toilets, setting up of electric/improved wood crematoria and river front development. Delay in completion of pollution abatement works by the States is mainly due to procedural issues in acquisition of land, contractual disputes, litigation etc. Cost escalation, if any, over approved/sanctioned cost of schemes due to such delay is to be borne by the respective State Governments.

#### 3.5.4 Gomti Action Plan.

94. Gomti Action Plan (GoAP) was approved along with the Yamuna Action Plan at an estimated cost of Rs.58.11 crore in April 1993. The approved cost comprises pollution abatement works in Lucknow (Rs 47.75 crore) and two other downstream towns Sultanpur (Rs. 4.70 crore) and Jaunpur (Rs. 5.66 crore).

95. DFID sanctioned a project in September, 1995 for preparing a detailed Master Plan of pollution abatement of the river and taking up some emergency works amounting to Rs.6.81 crore. These works included cleaning of some major drains, diversion of Gaughat Nalla away from the water intake point and renovation of a pumping station. All these works were completed in March 1999.

96. The issue of selection of technology for treatment of sewage took quite some time. The matter was finally resolved in consultation with the Planning Commission and the Government of U.P. Thereafter, the implementation of the first phase started from November 2000 onwards. So far, pollution abatement works amounting to Rs. 26.94 crore have been approved and are under different stages of implementation. These works include diversion of sewage of five nallas and a sewage treatment plant of 42 million litres per day (mld) capacity. An amount of Rs. 23.78 crore has been released to the implementing agency (U.P. Jal Nigam) against which, an expenditure of Rs. 17.64 crore has been incurred till data. These works are expected to be completed by March 2003. Completion of these works will result in addressing about 10% of the total pollution reaching the river.

97. In addition to the above works, an important component of the first phase presently under consideration for approval is diversion of Kukrail Nalla and balance city sewage to a point downstream of barrage. Undertaking of this work will ensure that a major portion of the remaining untapped sewage of the town will be discharged downstream of the barrage and as a result the water quality of the river in the core area of the city upstream of the barrage will improve. These projects are under consideration for approval by the Ministry and will take about three years to complete after sanction.

98. The U.P. Jal Nigam has recently submitted the detailed project proposal of the second phase works amounting to Rs. 280 crore. The project cost is to be shared in the ratio of 70:30 between Government of India (Rs. 196 crore) and State Government (Rs. 84 crore). The works in this phase will include two sewage treatment plants of a total capacity of 375 mld (over the 42 mld capacity being set up in the first phase), interception & diversion works of sewage of the remaining drains and other miscellaneous items like river front development, toilets, plantation, public awareness and participation, land acquisition etc. The project is presently under consideration of the Government of India for approval.

### 3.5.5 Damodar Action Plan

99. Under this Action Plan, pollution abatement works are being taken up in 12 towns. Of these eight are in Jharkhand and four in West Bengal. So far 11 schemes have been sanctioned. Out of the approved cost of Rs. 23.58 crore an expenditure of Rs. 6.43 crore has been incurred under this Action Plan. The work on the scheme has not yet begun in right earnest due to low priority given by the State Governments to this Plan.

### 3.5.6 National Lake Conservation Plan

100. A proposal for conservation and management of 10 polluted urban lakes was put up for consideration of Cabinet Committee on Economic Affairs (CCEA) in 1997. The CCEA only approved the proposal for Dal Lake Conservation Plan 'in principle' and asked the Ministry to seek external assistance for implementation of the National Lake Conservation Plan (NLCP). None of the external funding agencies viz.

101. The World Bank, JBIC, Government of Netherlands, Norwegian Government to which National Lake Conservation Plan was posed, evinced any interest in the project. The detailed project report of Dal Lake Conservation Plan has been prepared by AHEC, Roorkee and sent to the State Government of Jammu and Kashmir for their concurrence. The approval of Government of India for NLCP was accorded in May 2001 with the approval of proposal for conservation of three small lakes namely, Powai (Maharashtra) and Ooty and Kodaikanal (Tamil Nadu) using bioremediation technology at a cost of Rs. 14.90 crore as 100% Centrally Sponsored Scheme.

102. The work in respect of Powai and Ooty lakes is already initiated while the process of bidding for award of work is already completed in respect of Kodaikanal. The funding pattern under NLCP was revised to 70:30 cost sharing between Central and the State Government w.e.f. January, 2002. Under the pattern, proposal for conservation of 4 lakes in Bangalore were approved in February, 2002 at an estimated cost of Rs.12.32 crore with a central share of Rs.8.53 crore. The other proposals approved are those of Mansagar Lake at Jaipur at a cost of Rs.22.89 crore and Rabindra Sarovar at Kolkata for an estimated cost of Rs.6.96 crore. Proposals for 5 lakes in Nainital district including Nainital Lake, Bellandur and Kotekere in Karnataka and 9 lakes of Thane district in Maharashtra are under consideration for funding.

103. Other proposals submitted to the Ministry are those of lakes Mirik at Darjeeling (West Bengal), Banjara Lake at Hyderabad (Andhra Pradesh), Bhishma at Gadag (Karnataka). In view of a large number of proposals being received from various States, the scope of NLCP has been enlarged during the X Plan by including the rural lakes in the program along with urban lakes. The Plan outlay for X Plan period is Rs. 220 crore with an annual budget of Rs. 30 crore for 2002-03.

104. Activities covered under NLCP: Prevention of pollution from point sources by intercepting, diverting and treating the pollution loads entering the lake. The interception and diversion works may include sewerage & sewage treatment for the entire lake catchment area.

- i. In situ measures of lake cleaning such as de-silting, de-weeding, bioremediation, aeration, bio-manipulation, nutrient reduction, withdrawal of anoxic hypolimnion, constructed wetland approach or any other successfully tested eco-technologies etc depending upon the site conditions.
- ii. Catchment area treatment which may include afforestation, storm water drainage, silt traps etc.
- iii. Strengthening of bund, lake fencing, shoreline development etc.
- iv. Lake front eco-development including public interface.

- v. Solid waste management<sup>2</sup> & provision of dhobi ghats is generally not covered under NLCP.
- vi. Prevention of pollution from non-point sources by providing low cost sanitation.
- vii. Public awareness and public participation.
- viii. Capacity building, training and research in the area of Lake Conservation.
- ix. Any other activity depending upon location specific requirements.

### 3.5.7 Control of industrial effluent discharge

105. The government of India and the central and state pollution control boards have published standards that industrial effluents must meet before getting discharged. There are also a few popular technologies to achieve this.

## 3.6 Water quality monitoring in India

### 3.6.1 Inception of Water Quality Monitoring in India

106. The Central Pollution Control Board (CPCB) is responsible for restoration and maintaining the wholesomeness of aquatic resources under Water (Prevention & Control of Pollution) Act 1974 passed by Indian Parliament. On national and state levels, there are several policies and regulation like Water (Prevention and Control of Pollution) Act, 1974 to regulate pollution discharges and restore water quality of our aquatic resources including the prescription of monitoring activities. Under Water Act, 1974, pollution control boards were created, who are responsible for implementation of its provisions. One of the important provision of the Water Act, 1974 is to maintain and restore the 'wholesomeness' of aquatic resources. To define the level of 'wholesomeness to be maintained or restored a system of water use classification was developed. The Central Pollution Control Board (CPCB) is an apex body in the field of water quality management in India. For rational planning of any water quality management program, CPCB needs to know the nature and extent of water quality degradation. Therefore, a sound scientific water quality monitoring program is prerequisite. Realizing this fact, water quality monitoring was started in 1976 by CPCB with 18 stations on the Yamuna River. The program was gradually extended. Today, there are 1032 monitoring stations in the country spread over all important water bodies.

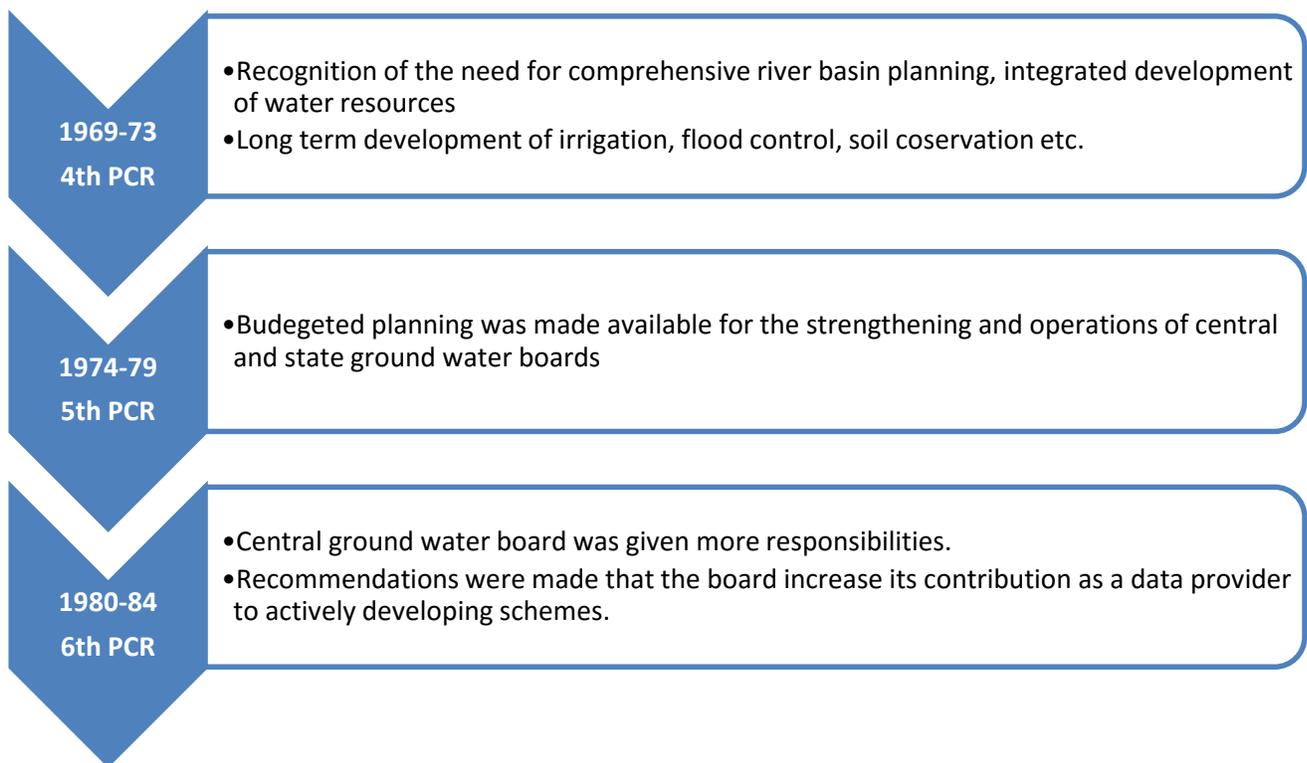
107. In the **4<sup>th</sup> planning commission report** comprehensive river basin planning, which takes due account of economic efficiency, was aimed to receive increased attention. Integrated development of water and land resources, master plans were deemed to be prepared for long-term development of hri-gation in each river basin, including inter-State rivers. In preparing these plans, the optimum economic development of a river basin covering various aspects such as irrigation, flood control, navigation and soil conservation was an envisioned requirement, however water quality issues were not identified at the time.

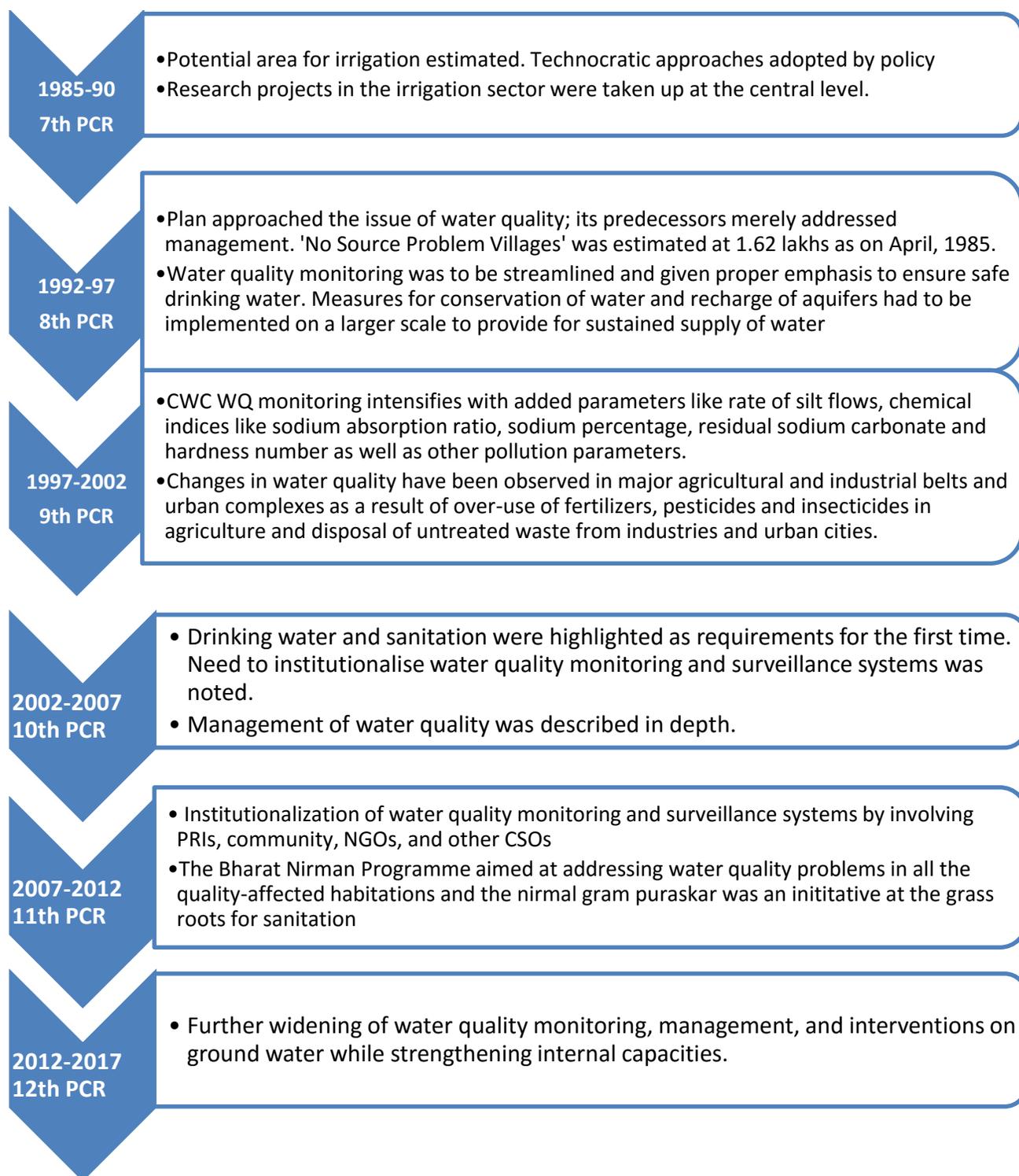
108. However, in the **5<sup>th</sup> five year plan (1974-79)**, budgeted planning was made available for the strengthening and operations of central and state ground water boards.

109. Progressing onto the **6<sup>th</sup> five year plan** the central ground water board was given more direction and responsibilities. The Central Ground Water Board was given three important functions in respect of Ground Water Development viz., (i) survey and investigation (ii) assessment and monitoring of acquirers and (iii.) exploratory tubewells. While it was felt that the Board has been doing very useful work in providing scientific data for ground water development in various parts of the country according to the varying lithology, its direct involvement in the implementation of ground water development schemes in the country was found to be very marginal. During times of emergency, like the drought in the various parts of the country in 1979, the Board had not been able to render sufficient assistance in drilling wells in the affected areas on account of paucity of rigs. The demand for the deposit wells to be drilled by the Central

Ground Water Board is increasing from States as also from Central Government Departments. Corporation etc. It was proposed to set up a Central Ground Water Corporation with head quarters located in a backward area like Basti or Balia in Eastern part of Uttar Pradesh which would take up exploitation of ground water in low utilisation areas. The Corporation, which was to work on commercial lines, would not only act as a catalyst for accelerating ground water development in the States but also provide training facilities. To begin with, the Corporation was to concentrate its work in the eastern region of the country and part of eastern Uttar Pradesh, Bihar, Orissa and Madhya Pradesh, where large untapped ground water potential existed. After the Corporation was set up, the Central Ground Water Board and the New Corporation would function in a mutually supportive manner. The Corporation would will endeavour to mobilise institutional finance for ground water development but initially some equity support would be needed from the Government- in the Sixth Plan, it was proposed to allocate Rs. 20 crores for initial setting up of Corporation and buying of new rigs etc.

**Figure 3.2: Progressive timeline of Planning Commission Reports on Water Quality Management**





110. **In 1985-90 with the 7<sup>th</sup> five year** planning commission report available data, indicated that the ultimate gross area irrigated can be much higher than 113 million hectares, if a national view was to be taken on the utilisation of water resources and consequent policy measures were adopted and full use was made of the technological advances such as inter-basin transfers of water, large-scale lifting of water from

streams and rivers through pumping, and modernisation of irrigation systems. Considerable scope and necessity for taking concerted measures to accelerate the pace of research activities in irrigation and flood control sectors was emphasized. Research projects in the Irrigation sector were taken up at the Central level by the Central Water and Power Research Station (CWPRS), Pune, Central Soil and Materials Research Station (CSMRS), New Delhi, National Institute of Hydrology (NIH), Roorkee, and Central Board of Irrigation and Power (CBIP), New Delhi and at the State level by State irrigation research institutes. Progress on research projects under CWPRS and CSMRS was slow due to delays at various levels such as preparation of projects for external aid, recruitment of staff and buying of equipment. Research projects sponsored by CBIP and carried out by State irrigation research institutes have progressed satisfactorily.

111. The major activities of the CWPRS cover model testing, basic research and evaluation of economic designs for ensuring safety and operational efficiency of the river valley projects at their formative stage. The CSMRS has been conducting basic and applied research and providing advice in the field of geo-mechanics and construction materials. The research station also renders consultancy services to the various departments of the Centre and State Governments. There was scope and necessity for expanding the activities of CSWPRS and CSMRS in fundamental research in irrigation. The NIH had so far carried out review of literature and testing of computer programs, collection of data, training of scientists, implementation in consultancy research projects for ground water modelling studies and Narmada Basin Flood studies. The Institute has identified priority areas for research in hydrology which would assist in the formulation of the river valley projects more objectively.

112. **The 8<sup>th</sup> 5 year (1992-1997)** plan approached the issue of water quality; its predecessors merely addressed management. The country had not yet been able to provide sustainable source of clean drinking water to all the people, particularly-in rural areas. Based on an identification done in 1980 and updated in 1985, the number of 'No Source Problem Villages' was estimated at 1.62 lakhs as on April, 1985. During the Seventh Plan period (1985-90), 1.54 lakh 'No Source Problem Villages' were provided with a source of drinking water supply, thus reducing the number of such villages to 8365 by the end of the Seventh Plan. At the commencement of the Eighth Plan period, there will be about 3000 no source problem villages. However, there are a large number of villages which are only partially covered and a large number of habitations which have no source at all or have highly inadequate supply. While the norms which are presently adopted envisage a source within a walking distance of 1.6 kms. or elevation difference of 100 metres in hilly areas and at last one handpump/spot source for every 250 persons, the accessibility of drinking water supply to the people will have to be progressively improved upon. Special and specific measures are also needed to tackle quality problems, such as, guineaworm, excess fluoride, high iron content and salinity.

113. Water quality monitoring was to be streamlined and given proper emphasis to ensure safe drinking water. Simultaneously, steps were needed to be taken for replacement and rejuvenation of defunct hand pumps/tubewells. Measures for conservation of water and recharge of aquifers had to be implemented on a larger scale to provide for sustained supply of water. Effort was needed to provide adequate quantity and quality of water and to make the sources sustainable.

114. **In the 9<sup>th</sup> 5 year plan that was from 1997 to 2002** resourced the Central Water Commission(CWC) maintain a large network of 877 hydrological observation stations in the key locations of the river basin systems of India for reliable assessment of the water resources of the country. Out of these, 319 stations distributed over all the major river basins, are also engaged in the water quality monitoring. Initially, the water quality monitoring of CWC was started with a limited objective of classification of water for irrigation and other related uses but later, it also included monitoring the rate of silt flows, chemical indices like sodium absorption ratio, sodium percentage, residual sodium carbonate and hardness number as well as other pollution parameters. However, the monitoring does not cover the municipal and industrial effluents. The CWC is also maintaining a three-tier laboratory system for analysis of the chemical parameters of water quality monitoring.

115. The ground water quality in India is being monitored by the Central Ground Water Board (CGWB) through a network of 14995 monitoring stations set up in different parts of the country. Changes in water quality have been observed in major agricultural and industrial belts and urban complexes as a result of over-use of fertilizers, pesticides and insecticides in agriculture and disposal of untreated waste from industries and urban cities. The ground water quality has also been affected in some parts of the country due to salinity ingress along the coastal area of some of the States like Saurashtra in Gujarat and Tamil Nadu. For planning and management of ground water system, it is necessary to set up a national data bank, where all the important information, covering various facets of ground water will be available. It is necessary that the data from all the concerned organisations in the States as well as at the Centre are stored on uniform formats and there should be easy access to the processed data. This will also help avoid duplication in efforts and investment.

116. **The 10<sup>th</sup> 5 year plan (2002-2007)** it was noted in the report of the steering committee for drinking water and sanitation that in view of increasing water quality problem and health hazards there from , it is necessary to institutionalise water quality monitoring and surveillance systems. Water quality surveillance should be done by an independent organization, more appropriately by the Health Department who should be provided with adequate budget provision for the same. Central assistance under the Centrally Sponsored Accelerated Rural Water Supply Program (ARWSP) shall be utilised for setting up stationary as well as mobile water testing laboratories in all the district headquarters.

117. In the 10<sup>th</sup> five year plan it is noted that in view of the increasing problem of water quality and the resultant health hazards, it is necessary to institutionalise water quality monitoring and surveillance systems. Water quality surveillance should be done by an independent organisation, more appropriately by the Health Department which should be provided with adequate funds for the task. Routine analysis of water samples for their physicochemical and microbial quality should be undertaken and monitored at the state level by the Public Health Department. Central assistance under the ARWSP shall be utilised for setting up stationary as well as mobile water testing laboratories in all district headquarters.

118. It was also realized that the community has to be made conscious about water quality through health education and awareness campaigns and water testing kits shall be made available to a range of institutions, including schools and colleges and qualified NGOs in the area.

119. The Mid-Term Appraisal of the Tenth Plan observed that over-reliance on groundwater for rural water supply program has resulted in the twin problem of sustainability and water quality and suggested a shift to surface water sources for tackling this issue. The observations of this mid-term evaluation included the following:

- i. There are about 2.17 lakh quality-affected habitations in the country with more than half of the habitations affected with excess iron (118088). This is followed by fluoride (31306), salinity (23495), nitrate (13958), arsenic (5029) in that order. There are about 25000 habitations affected with multiple problems. About 66 million population is at risk due to excess fluoride in 200 districts of 17 States. Arsenic contamination is widespread in West Bengal and it is now seen in Bihar, eastern UP, and Assam. The hand pump attached de-fluoridation and iron removal plants have failed due to in appropriate technology unsuited to community perceptions and their involvement. Desalination plants have also met a similar fate due to lapses at various levels starting with planning to post implementation maintenance. The Bharat Nirman Program aims at addressing water quality problems in all the quality-affected habitations by 2009. The problems of sustainability of water availability, maintenance of supply system, and dealing with the issue of water quality were the major challenges in the Eleventh Five Year Plan. The conjunctive use of groundwater, surface water, and rooftop rainwater harvesting systems will be required to be encouraged as the means of improving sustainability and drinking water security

- ii. Involvement of the community in the monitoring of the water supply works should be made a primary condition for release of funds for completed work. The DDWS has initiated monitoring of the water quality under the National Rural Drinking Water Quality Monitoring and Surveillance Program (NRDWQMSP) under which the Gram Panchayat/ Village Water and Sanitation Committee provided with user-friendly field test kits for testing both bacteriological and chemical contaminants followed by testing of the samples at district- and State-level laboratories. Such initiatives need to be extended to the other regular programs under the ARWSP also. Involving the community in bringing quality and sustainability to the village-level drinking water supply systems was also encouraged, rewarded, and recognized in an appropriate manner along the lines of the Nirmal Gram Puraskar that galvanized communities and local bodies for an enthusiastic and effective response to the TSC of the GoI

120. The **11<sup>th</sup> five year plan (2007-2012)** provided for substantial resources for water quality monitoring. By then, the CPCB, under MoEF, has established a nationwide network for water quality monitoring comprising 1019 stations in 27 States and six UTs. The monitoring is done on a monthly or quarterly basis for surface water and on a half-yearly basis for groundwater. The monitoring network covers 200 rivers, 60 lakes, five tanks, three ponds, three creeks, 13 canals, 17 drains, and 321 wells. Water samples are analysed for 28 parameters including physical parameters, nutrients, major ions, and organic and bacteriological parameters.

121. Effluent standards, environmental laboratories, and government analysts have been notified under the Environment (Protection) Act. There is a need for much stronger monitoring and enforcement for expanded coverage by both the Central and State Pollution Control Boards. Greater awareness and involvement of local (affected) communities and local governments in compliance and monitoring is critically important. While compliance will cover treatment and recycling of used water, monitoring should include the extent and quality of the treated water, and water quality of the water bodies providing or receiving the water in treated or untreated form. Information on the physico-chemical aspects of water quality in rivers and lakes has become available largely because of the support from the National River Conservation Directorate (NRCD) and the CPCB but that on aspects such as area, depth, hydrology, and ecosystem processes (functions) is practically non-existent. The existing programs on conservation accordingly need a revamp.

122. In order to achieve 100% coverage of clean water and sanitation, Eleventh Five Year Plan strategies include: Institutionalization of water quality monitoring and surveillance systems by involving PRIs, community, NGOs, and other CSOs.

123. The 11th plan recommended that Water quality surveillance and monitoring should be given top most priority by the State Governments/ULBs so as to ensure prevention and control of water-borne diseases. For this purpose, water quality testing laboratories were recommended to be set up in every city and town backed by qualified personnel to handle such laboratories and where such labs already exist, they should be strengthened with equipment, chemicals, manpower, etc., if necessary.

124. All in all, the 11<sup>th</sup> five year plan recognized the enormous issue that water quality in India has become and supplemented the report with suggestions and recommendations.

125. The 12<sup>th</sup> five year plan (2012-2017) suggested that Environmental Impact Appraisal conducted by the Ministry of Environment and Forests needs to include impact on groundwater based on inputs from CGWB. MoEF must be required to seek the opinion of CGWB in all groundwater stressed regions as well as in cases where a negative impact on water quality is anticipated. CGWB may develop protocols for conducting assessment of impact of major (industrial/urban/hydrological) interventions on groundwater and strengthen its own internal capacities to widen its scope of work.

126. With respect to Rural Drinking Water and Sanitation, the 12<sup>th</sup> Plan noted that the difficulty has been that even as coverage becomes universal, there is a growing problem of 'slipback', with habitations

suffering a fall in the water table and water quality, especially given the growing dependence on groundwater. Water quality has emerged as a growing concern, chemically due to geogenic leaching (arsenic and fluoride) and biologically due to bacteriological contamination. The fact that the same aquifer is being tapped for both irrigation and drinking water, without any coordinated management of the resource, has greatly aggravated availability of drinking water. Lack of convergence with sanitation, on the other hand, compromises water quality, even as it makes provision of improved sanitation difficult.

127. Given the growing importance of water quality issues, dedicated funding was provided to States with quality affected habitations, over and above the normal NRDWP allocation to the State. Within this dedicated funding highest priority will be given to arsenic and fluoride affected habitations. Part of the funding would also be made available to tackle bacteriological contamination in the priority districts with high incidence of JE/AES cases as identified by the Ministry of Health and Family Welfare.

### **3.7 Current Monitoring Networks and Protocol**

128. Water quality monitoring is carried out for various reasons and the objectives of a particular monitoring program have a direct bearing on the costs of carrying out the program. The most important objectives of water and effluent quality monitoring programs kept in mind by CPCB/SPCBs/PCCs include: - rational planning of pollution control strategies; - to identify nature and magnitude of pollution control required; - to evaluate effectiveness of pollution control efforts already in existence; - identification of state and trends in water quality, both in terms of concentrations and effects; - identification of the mass flow of contaminants in surface water and effluents; - formulation of standards and permit requirements; - testing of compliance with standards and classifications for waters and effluents; - early warning and detection of pollution.

129. In practice, data from routine monitoring programs are generally used for a variety of purposes in addition to those for which the programs were designed. Identification of the state and trends in water quality is mainly important for policy and management, while the identification of the mass flow in rivers and waste water discharges is of particular importance at the boundaries between states countries, districts or water systems. Mass flows are subject of international, national or state disputes, negotiations are an input for mass balances for specific substances. Testing of compliance with standards (control) is related to the water quality objectives for surface water as prescribed in both national and international standards. The early warning monitoring program to signal pollution due to (accidental) spills by industry and ships is especially important if surface water of that particular river or water system is used for public water supply.

130. Finally, data will be used for various projects including research. Water quality monitoring is an important aspect of overall water quality management and water resources development. A well planned and well managed water quality monitoring system is required to signal, control or predict changes or trends of changes in the quality of a particular water body, so that curative or preventive measures can be taken to restore and maintain ecological balance in the water body. Monitoring is essential for the successful implementation of environmental legislation: to ensure that standards and criteria set by CPCB/SPCBs/PCCs are maintained on a continuing basis.

131. CPCB in collaboration with concerned SPCBs/PCCs established a nationwide network of water quality monitoring comprising 2500 stations in 28 States and 6 Union Territories. The monitoring is done on monthly or quarterly basis in surface waters and on half yearly basis in case of ground water. The monitoring network covers 445 Rivers, 154 Lakes, 12 Tanks, 78 Ponds, 41 Creeks/Seawater, 25 Canals, 45 Drains, 10 Water Treatment Plant (Raw Water) and 807 Wells. Among the 2500 stations, 1275 are on rivers, 190 on lakes, 45 on drains, 41 on canals, 12 on tanks, 41 on creeks/seawater, 79 on ponds, 10 Water Treatment Plant (Raw Water) and 807 are groundwater stations

One of the function of the Central Pollution Control Board (CPCB), under the Section 16 2(b) of the Water (Prevention and Control of Pollution) Act, 1974 is to “coordinate the activities of the State Boards and resolve disputes among them. CPCB is monitoring water quality of rivers at the interstate borders since

2005. At present, the monitoring is carried out at 86 locations. Present report covers only 83 locations spread over 40 rivers. Monitoring frequency is preferably on quarterly basis though few river locations are monitored once in a year which are either small/seasonal or not carrying any interstate dispute.

**Table 3.1: State Wise Distribution of Monitoring Stations**

Name of State / UT	Number of CWC Monitoring Stations
Delhi	2
Andhra Pradesh	2
UT of Daman	2
Chattisgarh	2
Bihar	2
Jammu & Kashmir	2
Jharkhand	3
Tamil Nadu	3
West Bengal	5
Nagaland	3
Assam	2
Rajasthan	6
Odisha	6
Gujarat	7
Uttarakhand	9
Maharashtra	11
Karnataka	11
Punjab	11
Madhya Pradesh	13
Himachal Pradesh	14
Haryana	16
Uttar Pradesh	21

132. Central Water Commission monitors water quality at 371 key locations covering all the major river basins of India. CWC maintains a three tier Laboratory system for analysis of the parameters. The **Level-I Laboratories** are located at 258 field water quality monitoring stations on various rivers of India where physical parameters such as temperature, colour, odour, specific conductivity, total dissolved solids, pH and one Dissolved Oxygen of river water are observed. There are 24 **Level-II Laboratories** located at selected Division Offices to analyse 25 nos. physicochemical characteristics and bacteriological parameters

of river water. Four (04) **Level-III / II+ Laboratories** function at Varanasi, Delhi, Hyderabad and Coimbatore where 41 parameters including heavy metals / toxic parameters and pesticides are being analysed.

### 3.7.1 Protocols in the water quality monitoring and sampling procedures

133. Sampling is the first step in water quality monitoring and the sample should be truly representative.

134. Sample for physical and chemical analysis: The sample collection is through depth sampler which is built indigenously. The sampling depth is measured from the water surface to 0.6 percent for representative sampling. The depth sampler remains at the required depth for about 15 seconds before releasing the messenger device closes the sampler. The temperature of the sample is measured and recorded immediately after the sample is taken. For measurement of dissolved oxygen the sample is collected in DO bottle and fixed immediately. A DO sampler is used for collection of DO sample. If an electronic technique is being used, a portion of the sample is carefully poured into a beaker for measurement. For measurement of pH and conductivity separate portions of the sample should be collected. The same portion must not be used for both determinations because of the possibility of potassium chloride diffusing from the pH problem. All measurements taken in the field are recorded in the field notebook before leaving the sampling station.

135. Sample for Bacteriological analysis: Samples for Bacteriological analysis are taken in a sterile sampling bottle. Suggested chemical preservatives for samples are added in the field. Transportation and storage of samples. The sample collection process is coordinated with the laboratory. Sampling bottles are placed in a box for transport to the laboratory. Sturdy, insulated wooden or plastic boxes are used to protect samples from sunlight, prevent the breakage of sample bottles, and allow a temperature of 4 C to be attained and maintained during transport.

### 3.7.2 Laboratory Protocol

136. Samples received in Laboratory are analysed as per the NABL Protocol and ISO Guidelines/ Documentation. (ii) The instrumentation for analysis of different water quality parameters are spectrophotometer, pH meter, Colorimeter, Gas Chromatography (GC), Gas Chromatography – Mass spectroscopy (GC-MS), Inductively coupled plasma, Atomic absorption spectrophotometer (AAS), HPLC etc.

137. The CPCB experience with automatic water quality monitoring stations, when installed on River Ganga during 1990s was not fully satisfactory due many factors including the security/ safety of field equipment and instruments. Considering the practical feasibility and protection of the installed stations/ equipments, the automatic stations for water quality monitoring will be installed at abstraction points on rivers being operated by Central Government agencies such as Central Water Commission (CWC). It is also proposed to install these automatic stations on Polluted River Stretches.

138. In order to draw the water related action plans on the basis of reliable data, there is a need to maintain uniformity in the procedure for water quality monitoring mechanism by all monitoring agencies, departments, Pollution Control Boards and such other agencies. Accordingly, the Central Government notified the “Uniform Protocol on Water Quality Monitoring Order 2005”. The order is allocable to all organizations, agencies and any other body monitoring surface and ground water quality in the country. The order incorporates guidelines related to selection of monitoring stations, frequency of sampling, parameters to be analyzed, procedure for sample collection, its preservation and transportation, maintenance of sample records and other aspects related to water quality monitoring.

139. The Water Quality Assessment Authority (WQAA) was constituted by the Central Government to exercise powers of the Environment (Protection) Act, 1986 for issuing directions and for taking measures

to standardize method(s) for water quality monitoring and to ensure quality of data generation for utilization thereof and certain other purposes.

140. It is deemed necessary and expedient to evolve water quality assessment and monitoring protocol as directed by the Water Quality Assessment Authority in order to maintain uniformity in the procedure for water quality monitoring mechanism by all monitoring agencies, departments, Pollution Control Boards and such other agencies so that water related action plans may be drawn up on the basis of reliable data.

141. The uniform process on water quality monitoring shall provide frequency of monitoring, procedure for sampling, parameters for analysis, analytical techniques, quality assurance and quality control system, infrastructure requirement for laboratories, procedure for data processing, reporting and dissemination and such other matters as the Central Government deems necessary for both surface and ground water.

142. **Sample Collection:** The procedure for sample collection in respect of surface water: includes that samples for Baseline and Trend stations shall be collected from well-mixed section of the river or main stem 30 cm below the water surface using a Dissolved Oxygen (DO) sampler or weighted bottle. Samples for Impact stations shall be collected from the point of interest, such as bathing ghat, downstream of point discharge, water supply intakes and other sources. The Dissolved Oxygen (DO) in the sample shall be fixed immediately after collection and Dissolved Oxygen (DO) analysis shall be done either in the field or in laboratory.

143. The procedure for sample collection in respect of ground water included that the open dug wells, which are not in use or have been abandoned, shall not be considered as water quality monitoring station. However, such well could be considered for water level monitoring. Weighted sample bottle to collect sample from an open well about 30 cm below the surface of water may be used. The plastic bucket, which is likely to skim the surface layer only, shall not be used. Samples from the production tube wells shall be collected after running the well for about five minutes. Non-production piezometers shall be purged using a submersible pump. The purged water volume shall equal 4 to 5 times the standing water volume, before sample is collected.

144. For bacteriological samples, when collected from tube wells or hand pump, the spout or outlet of the pump shall be sterilized under flame by spirit lamp before collection of sample in container.

145. Each laboratory shall have a bound register, which shall be used for registering samples as they are received. The Laboratory In-charge shall maintain a register for assignment of work to specific analyst. Each agency shall follow the analytical techniques prescribed in the Standard Methods for Analysis of Water and Wastewater published by American Public Health Association (Latest Edition) or Bureau of Indian Standard(BIS) Methods for Testing Water and Wastewater-methods of sampling and testing (physical and chemical)

146. **Analysis records and data validation:** a recommended format for recording data including all parameters except toxic metals and trace organics is enclosed as Form – IV. Report of heavy metals and trace organics as per Table 2 may be recorded separately. Validation checks should be performed in the laboratory on completion of the analysis. The results of laboratory analyses shall be entered in the format provided in Form – II for validation.

147. **Manpower requirements in laboratories:** The manpower requirements shall be optimized by the concerned monitoring agencies in order to get the maximum utilization of mandays, for timely completion of analysis.

148. **Data Processing, Reporting and Dissemination:** each monitoring agency shall process the analytical data and report the data after validation to the Data Centre at the Central Pollution Control Board. The Central Pollution Control Board shall store the data and disseminate through website or electronic mail to various users on demand.

149. **Quality Assurance and Accreditation of Laboratories:** The Quality Assurance Program for the laboratories of various agencies shall contain a set of operating principles, written down and agreed upon by the organization, delineating specific functions and responsibilities of each person involved. Each laboratory of water quality monitoring agencies shall follow the guidelines of Quality Assurance Program prescribed by their respective Central Laboratory or Headquarters and shall participate in Inter Laboratory Quality Assurance Program like Proficiency Testing (PT) organized by them or any other agency on regular basis. The Water Quality Laboratories shall seek recognition from the Ministry of Environment and Forests, Government of India or accreditation from National Accreditation Board for Testing and Calibration Laboratories (NABL) under the Ministry of Science and Technology, Government of India.

### 3.8 Water Quality in various River basins

#### 3.8.1 Indus:

150. The geographical extent of the basin is between 72°28' to 79°39' east longitudes and 29°8' to 36°59' North latitudes of the country with a maximum length and width of 756 km and 560 km. The length of Indus River in India is 1114 km. The total catchment area of the basin is 321289 Sq. Km.

151. The Indus basin extends over China (Tibet), India, Afghanistan and Pakistan draining an area of 11, 65,500 Sq.km. The principal tributaries lying on the left of the Indus area the Jhelum, Chenab, Ravi, Beas. The basin spreads over 32 parliamentary constituencies( 2009) comprising 13 of Punjab, 7 of Jammu & Kashmir, 4 each of Himachal Pradesh and Haryana, 3 of Rajasthan and 1 of Chandigarh with total population of 37476080.

152. The Indus basin is subdivided into 11 sub basins. The sub basins are Gilgit Sub-basin, Lower Indus Sub-basin, Shyok Sub-basin, Jhelum Sub-basin, Upper Indus Sub-Basin, Chenab Sub-Basin, Ravi Sub-basin, Beas Sub-basin, Satluj upper Sub-basin, Satluj lower Sub-basin, Ghaggar and other sub-basin.

153. **Surface water quality issues:** The monitoring results indicated that organic pollution continues to be the predominant pollution of aquatic resources. The organic pollution measured in terms of bio-chemical oxygen demand (BOD) & Coliform bacterial count gives the indication of extent of water quality degradation in different parts of our country. The river water quality in the Himalayan Segment and the Diluted Segment is comparatively good. However, due to heavy abstraction and discharge of pollutants into the river system, the lower segments are very highly polluted.

154. **Ground water quality issues:** The groundwater is marginal to brackish in quality in 60 percent of the Indus Basin. Flourine, Chlorides, Nitrates, and iron have found to be present in concentrations higher than permissible limits in certain areas of the river. Overexploitation of ground water increases the salinity of ground water and excessive use of fertilizers and pesticides in agriculture and improper disposal of urban/industrial waste can cause contamination of ground water resources.

#### 3.8.2 Ganga:

155. The Ganga river basin is the largest of the basins of India with an area of 8,61,452 Sq.km in India, draining into the 11 states of the country, Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh and West Bengal. The Ganga river has many tributaries, both in the Himalayan region before it enters the plains at Haridwar and further downstream before its confluence with the Bay of Bengal. The basin has a total drainage length of about 624235.73 Sq.km. The Ganga basin lies between east longitudes 73°2' to 89°5' and north latitudes 21°6' to 31°21' having maximum length and width of approx. 1,543 km and 1024 km.

156. The vast **Gangetic** alluvial trough is characterized by not only one of the most prolific aquifers in quantitative terms, but also by the relatively high quality of the available water, though the quality deteriorates as one proceeds down the river to the outfall.

157. **Surface water quality issues:** The river water quality in the Himalayan Segment and the Diluted Segment is comparatively good. However, due to heavy abstraction from and discharge of pollutants into the river system, the lower segments are very highly polluted. The pH value is an important criterion for drinking purposes with the desired range of 6.5-8.5 and the value of pH in the Ganga basin is observed in the range of 6.5-8.9.

158. The desired criterion of Conductivity for irrigation is 2250  $\mu\text{mhos/cm}$ . and the value for the basin range between 68-4460  $\mu\text{mhos/cm}$  and thus not meeting its required criteria. The Dissolved Oxygen (DO) and Bio chemical Oxygen Demand (BOD) is an important parameter for aquatic life of flora and fauna. The desired value for DO should be more than 4 mg/l and for BOD should be less than 3 mg/l. The observed value for DO and BOD in the basin lies in the range of 4.3-9.2 mg/l and 0.2-16.0 mg/l. respectively and doesn't meet the criteria.

159. The Faecal Coliform should be less than 2500 MPN/100ml whereas the value for the basin ranges from 0-400000 MPN/100ml. The Faecal Coliform is not complying with the permissible limit of water quality criteria for bathing.

160. In very few tributaries the pH meets the criteria, while in most tributaries the pH is highly basic. At most test points the DO, BOD, faecal coliform and total coliform do not meet the criteria, indicating high levels of pollution in the surface water. The Water Quality Status of canal in Ganga basin is also affected to a large extent. The Western Yamuna Canal downstream of Yamuna Nagar and at Damla is grossly polluted due to municipal and industrial waste water disposal.

161. **Ground water quality issues:** The hot spots for groundwater in districts coming under basin states are identified on the basis of six main parameters: salinity ( $\text{EC} > 3000$  micro simen/cm), chloride, fluoride ( $> 1.5$  mg/l), iron ( $> 1.0$  mg/l), arsenic ( $> 0.05$  mg/l) and nitrate ( $> 45$  mg/l).

162. The states of Bihar, Uttar Pradesh and West Bengal is affected by arsenic (where the concentration is greater than the permissible limit of 0.05 mg/l as per IS: 10500), fluoride, iron & nitrate. More than permissible level of salinity and chloride has been identified in Haryana, Delhi, Himachal Pradesh, West Bengal, Uttar Pradesh, Rajasthan and Madhya Pradesh.

163. In the central alluvial trough, the groundwater has low mineral contents. The mineral content increases near the southern fringe of the alluvial formation.

164. According to the CGWB, the Ganga basin is severely affected by arsenic, fluoride, nitrate, chloride and salinity. The problem of arsenic contamination in ground water from the vast tract of alluvial aquifers in West Bengal, Bihar and Uttar Pradesh has affected a large population in different districts of Ganga basin. In the Ganga basin relatively high values of EC exceeding the permissible limit of 3000  $\mu\text{S/cm}$  are observed in many parts.

### 3.8.3 Brahmaputra:

165. Brahmaputra basin spreads over 580,000 Sq.km spreads over China (50.5%), India (33.6%), Bangladesh (8.1%) and Bhutan (7.8%). Although the main river does not flow through the kingdom of Bhutan, 96 % of Bhutan's area falls under this Basin. In India, the catchment area spreads over states of Arunachal Pradesh, Assam, West Bengal, Meghalaya, Nagaland and Sikkim covering 1,94,413 Sq. km. which is nearly 5.9 % of the total geographical area of the country. The basin lies between  $88^{\circ}11'$  to  $96^{\circ}57'$  east longitudes and  $24^{\circ}44'$  to  $30^{\circ}3'$  north latitudes. The upper portion of the basin (Indian part) lying in Arunachal Pradesh, Nagaland and the some lower portion of the basin falling in Sikkim is mostly mountain ranges and narrow valleys.

166. When compared to the other major rivers in India, the **Brahmaputra** is less polluted but it has it is also facing problem of water pollution due to petroleum refining units draining most of the industrial pollution load into the river along with other medium and small industries

167. **Surface water quality issues:** High bi-carbonate content and source rock influence. Surface suspended sediments range from fine sand to clay, the size fraction greater than 12 $\mu$ m constitute a large number. Surface suspended sediments are moderately to poorly sorted with greater amounts of finer material in the distribution, particularly during the rainy season. The detrital contribution in the form of Quartz, Feldspar and Mica make up more than 80% of the mineralogy.

168. It has been also observed that river water of the basin is generally alkaline with comparatively high bicarbonate, sulphate and dissolved silica concentration. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Fecal Coliform and turbidity are observed to be the common violating parameters for most of the rivers of the basin.

169. **Ground water quality issues:** At many places in the basin, an excess of Fluoride, Iron and Arsenic has been recorded. High Levels of Arsenic in groundwater not only cause significant problems in the provision of Safe Drinking water. Long term exposure of arsenic has been associated with cancer of the skin, lung, urinary tract, kidney, liver, and can also produce various other non-cancerous effects.

#### 3.8.4 Barak & others:

170. The basin covers parts of India, Bangladesh and Myanmar. In India it spreads over states of Meghalaya, Manipur, Mizoram, Assam, Tripura and Nagaland covers an area of 45,622.12 Sq.km (GIS based calculated area), which is nearly 1.38% of the total geographical area of the country. The basin extends between 89° 50' E to 94° 0' E and 22° 44' N to 25° 58' N with maximum length and width of 460 km and 350 km. It is bounded by the Barail range separating it from the Brahmaputra basin on the north, by the Naga and Lushai hills on the east and by Mizohills and territory of Bangladesh on the south and west.

171. **Surface water quality issues:** The basin has good quality of ground water except for high dissolved iron content at some places, and very few places are affected to salinity. In general the basin yield of the wells in these areas varies from 16 to 62 m<sup>3</sup>/hr. The thickness of saturated zone is 30 to 70m with in 300 m depth one an average, the wells of 250 m depth can yield between 20-30m<sup>3</sup>/hr. The quality of ground water is generally good.

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173. In Manipur and Meghalaya ground water in the State is characterized by low salinity. In Tripura the quality of water is good except for a slightly high content of iron at various places and in Nagaland the quality of ground water is generally very good.

#### 3.8.5 Godavari:

174. The Godavari is the second largest basin and accounts for nearly 9.5% of the total geographical area of the country. It extends over states of Maharashtra (48.7%), Andhra Pradesh (23.7%), Chhattisgarh (12.4%) and Odisha (5.7%) in addition to smaller parts in Madhya Pradesh (7.8%), Karnataka (1.4%) and Union territory of Puducherry (0.01%). The basin falls under division-All drainage flowing into Bay of Bengal and Region-Rivers draining in Bay of Bengal, delineated primarily based upon drainage of rivers to outlet. It extends over an area of 302065.10 Sq. km, with a maximum length and width of about 995 km and 583 km, respectively. The CWC reported area of the basin is 312812.0 square km.

175. **Surface water quality issues:** Bureau of Indian Standards (BIS) has fixed tolerance limits of water quality in Indian context following the tolerance limits of WHO. The Bureau of India Standards has identified 42 water quality parameters and fixed tolerance limit for each parameters. The Godavari basins have reported tolerance limit for 33 water quality parameters. The critical absolute values of water quality parameters for Godavari basin have crossed tolerance limit throughout the year.

176. **Ground water quality issues:** Concentrations above permissible limits of TDS, pH, and Mg have been recorded in the Godavari Upper Sub-Basin. NO<sub>3</sub> and pH concentrations above permissible limits have been recorded in the Godavari Lower Sub-Basin. Pranhita Sub-basin shows at places, high value for NO<sub>3</sub>, F and pH. The sources of pollution are domestic and industrial wastewater from the large cities in Maharashtra and Mancherial, Ramgundam, Rajahmundry, Godavarikhani, Burgampahad and Bhadrachalam cities in Andhra Pradesh. Depletion of dissolved oxygen has been reported due to addition of sewage into the river besides bacteriological pollution.

### 3.8.6 Krishna:

177. The Krishna Basin extends over the states of Andhra Pradesh (29.81%), Maharashtra (26.36%) and Karnataka (43.8%). Krishna Basin has a total area of 258948 sq. km which is nearly 8% of the total geographical area of the country. The basin has a maximum length and width of about 701 km and 672 km and lies between 73°17' to 81°9' east longitudes and 13°10' to 19°22' north latitudes. The basin is roughly triangular in shape and is bounded by Balaghat range on the north, by the Eastern Ghats on the south and the east and by the Western Ghats on the west.

178. **Surface water quality issues:** Bhadravati in Karnataka and Patancheru- Bolaram in Andhra Pradesh are the critically polluted areas identified in the basin area of Krishna. For Bhadravati the major source of water pollution is the waste water generated from industries besides the untreated sewage of the town, which is being discharged into Bhadra. Conductivity is not meeting the criteria at Hamsala Deevi in Andhra Pradesh due to estuarine region. Dissolved oxygen is lower in many areas of the basin. High values of biological oxygen demand (BOD) are also observed in many areas of the basin. Fecal coliform meets the criteria while total coliform is present in high values in Tungabhadra in Maharashtra.

179. **Ground water quality issues:** Industries are polluting ground water in the region. The salinity of ground water in coastal areas may be due to air borne salts originating from air water interface over the sea and also due to over pumping of fresh water which overlays saline water in coastal aquifer systems. Many districts are affected by high chloride in the water. Over half a dozen districts in Andhra and Karnataka show a high presence of flourides in the water. Nitrate in ground water generally originates from nonpoint sources such as leaching of chemical fertilizers & animal manure, ground water pollution from septic and sewage discharges etc. Iron too is found in higher than permissible concentrations in many districts through which the Krishna flows.

### 3.8.7 Cauvery:

180. The Cauvery basin extends over states of Tamil Nadu, Karnataka, Kerala and Union Territory of Puducherry, draining an area of 85,626.23 Sq.km. Out of this, 42% area lies in Karnataka, 54% area in Tamil Nadu & Karaikkal region of Puducherry and 4% in Kerala. It falls in peninsular India and lies between 75°27'E to 79°54'E and 10°9'N to 13°30'N. It is bounded by the Western Ghats on the west, by the Eastern Ghats on the east and south and by the ridges separating it from Krishna basin and Pennar basin on the north. The three main physiographic division of the basin are the Western Ghats, the plateau of Mysore and the Delta.

181. **Surface water quality issues:** The untreated sewage waste and effluents of major towns situated along the river also flow into the main stream of river and degrade its quality for use in irrigation and drinking purposes.

182. **Ground water quality issues:** The chemical quality of ground water, both from near-surface and deeper aquifer zones, is generally good and suitable for the irrigation and drinking purposes in the basin.

#### 3.8.8 Subernarekha:

183. Subernarekha basin extends over the states of Jharkhand, Odisha and comparatively smaller part in West Bengal having a total reported area of 29,196 Sq.km and geographically calculated area of 25,792.17 Sq.km with a maximum length and width of about 297 km and 119 km.

184. **Surface water quality issues:** The prominent parameters which have crossed the tolerance limits frequently are Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD). Industries and towns generate effluents, sewage wastes and considerable quantities of wastewater which are discharged directly into the river. A drop in dissolved oxygen, accompanied by decrease in plankton, has been reported below the discharge point. Due to natural processes, river water recovers its quality further downstream

185. **Ground water quality issues:** From the data available it is found that for the site named Chakulia, a considerable increase in amounts of chlorine and sodium is seen. Chlorine and Sodium content in the ground water have both increased over the years.

#### 3.8.9 Bhramani & Bhaitarni:

186. The Brahmani and Baitarni basin is the 17<sup>th</sup> largest basin having total catchment area of 51907.45 Sq.km which is nearly 1.7% of the total geographical area of the country. The basin spreads from 83°55' to 87°3' east longitudes and 20°28' to 23°38' north latitudes on Indian sub-continent. The basin is bounded by the Chhotanagpur Plateau on the north, by the ridge separating it from Mahanadi basin on the west and the south and by the Bay of Bengal on the east. The maximum length and width of the basin is 403 km and 193 km. The basin is further divided into two sub-basins namely Brahmani and Baitarni. The Brahmani sub basin covers 37,545 Sq.km.

187. **Surface water quality issues:** According to the studies made by CPCB, the observed water quality status of Baitarni River and its tributaries are below the desired class. The Brahmani Baitarni river basins hold extremely rich mineral resources. Consequently, many industrial units including the famous Rourkela Steel Plant as well as a number of fast growing townships are located here. The river becomes incapable of washing down the pollutants, which are discharged into it from the nearby industries, towns and villages. Greater part of Brahmani River, below Panposh, is highly polluted.

188. **Ground water quality issues:** Brahmani, turns in the summer into more or less a stagnant pool of water held in deep gorges and pot holes in the river bed. The river becomes incapable of washing down the pollutants, which are discharged into it from the nearby industries, towns & villages. Greater part of the Brahmani River (below Panposh) is highly polluted. From the water quality point of view, the observed quality is below the desired class in general, it is better at a few places. Here too, BOD and total coliform are critical parameters. According to the studies made by CPCB, the observed water quality status of Baitarni River and its tributaries are below the desired class.

#### 3.8.10 Mahanadi:

189. The Mahanadi is the 8<sup>th</sup> largest basin having total catchment area of 139681.51\* Sq.km which is nearly 4.28% of the total geographical area of the country. The geographical extent of the basin lies between 80°28' and 86°43' east longitudes and 19°8' and 23°32' north latitudes. It is physically bounded in the north by Central India hills, in the south and east by the Eastern Ghats and in the West by Maikala hill range.

190. **Surface water quality issues:** According to data given in 'Integrated hydrological data 2012, CWC, the critical absolute values of water quality parameters for Mahanadi basin exceeded tolerance limit during the winter season of 2009-10. The prominent parameters which have crossed the tolerance limits

frequently are Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD). The Mahanadi river basins have reported the tolerance limit for 11 water quality parameters only.

191. **Ground water quality issues:** Mahanadi delta occurs on the east coast of India, in the state of Orissa. Groundwater is a major source of fresh water in the area. The permeable sand and gravel layers in the unconsolidated sediments form the potential aquifers, having a cumulative thickness of 15-65 m. Groundwater occurs under both confined and unconfined conditions. The depth to water table varies from less than 2 m to 4 m below ground level. The well yields vary from less than 35 m<sup>3</sup>/hr in the basin marginal areas in the west to more than 270m<sup>3</sup>/hr in the coastal plains in the east. K and S values of the deeper aquifers are in the range of 5-330 m/day and  $1.75 \times 10^{-2}$ - $8.81 \times 10^{-6}$  respectively. But the aquifers are beset with salinity hazards. The saline and fresh water profile is non-uniform with freshwater overlying/underlying or alternating with saline zones, or with saline water at all depths. However, the ground water quality is in general fresh (EC<1600  $\mu$ S/cm) and suitable for all uses, except in areas having high salinity, and in localized pockets showing high concentration of iron, fluoride, nitrate and sulphate being injurious to health. The annual groundwater recharge is of the order of 351069 HAM, with gross draft of 39688 HAM.

### 3.8.11 Pennar:

192. Located in peninsular India, the Pennar basin extends over states of Andhra Pradesh and Karnataka having an area of 55,213 Sq.km with maximum length and width of 433 km and 266 km. The basin lies between 77°1' to 80°10' East longitudes and 13°18' to 15°49' North latitudes. The fan shaped basin is bounded by the Erramala range on the North, by the Nallamala and Velikonda ranges of the Eastern Ghats on the East, by the Nandidurg hills on the South and by the narrow ridge separating it from the Vedavati valley of the Krishna Basin on the West.

193. **Surface water quality issues:** Surface water means water at or above the land's surface which is neither ground water nor contained within the unsaturated zone. CWC stations carry out observations for testing the surface water quality pertaining to sixty eight water quality parameters which are considered to be the 'Standard Hydrology Project Water Quality Parameters'. All physical, chemical and biological water quality parameters are categorized further under sub categories like field determinations, nutrients, organic matter, alkalinity, hardness, other inorganics, major ions, coliforms and others.

194. **Ground water quality issues:** The Pennar water possess high silt load during monsoon period resulting acute drinking water problems for people in rural areas who directly depend on it. In Andhra Pradesh, ground water occurs under unconfined and semi confined conditions. Rainfall is the principal source of recharge; the others being percolation of river water during high flow periods and seepage of irrigation water. During summer (low flow) period, ground water contributes to base flow. Among the cations and anions present in the ground water sodium and chloride are predominant in Andhra Pradesh region.

### 3.8.12 Mahi:

195. The Mahi basin extends over an area of 34,842 Sq. km. and lies between 72° 21' E to 75° 19' E and 21° 46' N to 24° 30' N. The basin is bounded in the north and the north-west by Aravalli hills, in the east by the Chambal basin, in the south by the Vindhyas and in the west by the Gulf of Khambhat. Mahi river originates at a place (22° 35' N and 74° 58' E), near the village of Sardarpur in the Dhar district of Madhya Pradesh. The basin is comprised of two sub-basins:- Mahi upper sub basin (65.11% of total basin area) consisting of 41 watersheds and Mahi lower sub basin (34.89% of total basin area) consisting of 22 watersheds.

196. **Surface water quality issues:** Generally the water bodies in the basin provide water suitable for irrigation, fisheries and water supply

197. **Ground water quality issues:** The quality of ground water deteriorates as the depth of the aquifer increases. There is a gradual increase in the salinity of ground water towards the coast. The fresh water zone gradually tapers off towards the west. Patches of alluvium occurs across the Mahi and Panam rivers, the most significant and promising patch being on the north side of the Mahi river between Charangam and Harod.

### 3.8.13 Sabarmati:

198. Sabarmati River is one of the major west flowing rivers of India. The Sabarmati basin extends over the states of Rajasthan and Gujarat having an area of 21,674 Sq. km with maximum length and width of 300 km and 150 km respectively. It lies between 70°58' to 73°51' east and 22°15' to 24°47' north. The basin is bounded by Aravalli hills in the north and north-east, Rann of Kutch in the west and Gulf of Khambhat in the south.

199. **Surface water quality issues:** Sabarmati River is notorious for being almost depleted of dissolved oxygen during summer or pre-monsoon months. However, the situation has improved after the Narmada canal has started supplying water to some places in the basin due to dilution effect. It is also a matter of concern that at some places.

200. **Ground water quality issues:** As per studies about Ground water potential has been made in parts of Mehsana, Sabarkantha, Ahmedabad and Kaira districts of Sabarmati basin. Observations in Mehsana district indicate that the quality of Ground water deteriorates progressively from east to west. The water is of good quality and the feasibility of tapping the sandstones in selected parts has been confirmed.

### 3.8.14 Naramada:

201. Narmada basin extends over an area of 92,672.42 Sq.km and lies between east longitudes 72° 38' to 81°43' and north latitudes 21° 27' to 23° 37' which is nearly 3% of the total geographical area of the country.

202. The basin is bounded on the north by the Vindhya, on the east by the Maikala range, on the south by the Satpuras and on the west by the Arabian Sea. Lying in the northern extremity of the Deccan plateau, the basin covers large areas in the States of Madhya Pradesh, Gujarat and a comparatively smaller area in Maharashtra and Chhattisgarh.

203. **Surface water quality issues:** As compared to the other rivers, the quality of Narmada water is quite good.

204. **Ground water quality issues:** Occurrence of fluoride in ground water has been found in many districts of Madhya Pradesh. There are also concerns about the ground water quality in Bharuch with the chemical units there pumping their effluents into the aquifers leading to heavy pollution of ground water. Tests have revealed that the mercury levels in the ground water near the Ankleshwar Industrial Estate are more than 100 times the admissible levels. This has been compounded by saline ingress from the sea due to heavy drawls of ground water in the area. Throughout the plains areas of the basin there is the problem of chemical residues from agriculture entering the ground water and this is reflected in the fact that about 40% of the ground water sample collection sites of the Central Ground Water Board.

### 3.8.15 Tapi:

205. It covers a large area in the State of Maharashtra besides areas in the states of Madhya Pradesh and Gujarat. The Tapi Basin is the northern-most basin of the Deccan plateau and is situated between latitudes 20°N to 22°N approximately. The basin extends over states of Madhya Pradesh, Maharashtra and Gujarat having an area of 65,145 Sq.km out of which nearly 80 percent area lies in Maharashtra state. It lies between 72°33' to 78°17' east longitudes and 20°9' to 21°50' north latitudes. Situated in the Deccan plateau the

Satpura range forms its northern boundary whereas the Ajanta and Satmala hills form its southern extremity. Mahadeo hills form its eastern boundary. The basin finds its outlet in the Arabian Sea in the west.

206. **Surface water quality issues:** Physico-chemical parameters temperature, pH, conductivity, dissolved oxygen, chemical oxygen demand, nitrate-n, total hardness, fluoride, chloride, total alkalinity and sodium were within the permissible limits whereas turbidity, biological oxygen demand, nitrite-n ammonia, phosphate and potassium were beyond the permissible limits of state, national and international authorities like Gujarat Pollution Control Board, Central Pollution Control Board, World Health Organisation and United States Environmental Protection Agency.

207. The water of downstream of Ukai, Tapi River is polluted due to presence of plant nutrient like N, P and K that might be accumulated from agricultural activities and its runoff in and around catchment area of downstream of Ukai, Tapi River.

208. **Ground water quality issues:** Ground waters were relatively free from such contamination because of the filtering effect of the strata of soil through which the water percolates, but, over the decades industrial contaminants have begun to show up even in ground waters.

**Table 3.2: Major Water Quality Issues in India**

	Main Water Quality issues	Main affected people/ economic activity
1	Low Biological oxygen demand	Discharge of untreated sewage is the single most important source of pollution of surface and ground water in India
2	High Coliform levels	Affects agriculture and thereby communities who base their livelihoods on agriculture as well as consumers. There are significant associations between water-borne/enteric disease and the use of the river for bathing, laundry, washing, eating, cleaning utensils, and brushing teeth. It is also correlated to contracting dysentery, cholera, hepatitis, as well as severe diarrhea which continues to be one of the leading causes of death of children in India
3.	Seasonal variations of ground water levels	It's caused by over exploitation by agriculture and industries. Groundwater is a critical resource in India, accounting for over 65% of irrigation water and 85% of drinking water supplies thereby making it a cyclical problem
4.	Chemical pollution	High mercury, flourides, iron and other elemental pollution links water security with food security issues as chemical pollution enters the food chain via irrigation and is taken up by crops. As it does not break down this can in turn affect consumers far away.
5.	Treatment of water	On the banks of the ganga, many individual washermen, and other low income entrepreneurs are adversely affected with the governments action to clean the river by not allowing polluting activities to take place on the banks of the river. Displacing them severely affects their incomes.

### 3.9 Links between ground water and surface water quality

209. Along with human activity that affects the quality and interaction of surface and ground water interaction in a river, the natural physical mechanisms are briefly described below.

210. Groundwater and surface water are essentially one resource, physically connected by the **hydrologic cycle**. Although water law and water policy often consider groundwater and surface water as separate resources, groundwater and surface water are functionally inter-dependent. Groundwater and surface water interactions are controlled by their hydraulic connection.

211. **Hydraulically Connected Systems:** If the groundwater table is in physical contact with the stream bed, it is a hydraulically "connected" system. The exchange of water between the groundwater system and a stream is controlled by the difference in elevation between groundwater table and the water level in the stream.

212. **Gaining stream:** In a gaining stream, groundwater levels are above the water level in the stream. Under these conditions, the groundwater system discharges water to the stream, increasing flow in the stream. Under natural conditions, prior to the pumping of groundwater from wells, streams are the primary discharge outlet for groundwater: rainfall percolates into the ground and recharges the groundwater system, and then water flows very slowly through the groundwater system, eventually discharging to streams. Groundwater discharge to streams provides the baseflow of streams and is often a primary component of the total streamflow. When groundwater wells are developed, pumping captures water that would otherwise discharge to streams, which decreases the baseflow to the streams. This decrease in groundwater discharge to streams, caused by pumping, is called stream depletion. Groundwater can also discharge to lakes, wetlands and other similar habitat in low-lying areas when groundwater is near the surface. Like streams, groundwater discharge to these surface water features is reduced by groundwater pumping.

213. **Losing streams:** In losing streams, groundwater levels are lower than water levels in the stream, and water from the stream recharges the groundwater system. Several different conditions can cause a stream to be a losing stream. For example, if groundwater pumping is sufficient to lower regional groundwater levels or if a well is located very near a stream, groundwater levels can drop below stream levels, inducing groundwater recharge from streams. These conditions can persist for months or years. This loss of water from stream flow, caused by pumping, is also called stream depletion.

214. Natural conditions, such as flood events, can also create losing-stream conditions. During flood events, stream levels can temporarily rise above groundwater levels, causing streams to recharge the groundwater system adjacent to the stream. However, when water levels in the stream return to normal, this water will drain back into the stream. This rapid exchange of water between the stream and the groundwater system during flood events is not called stream depletion.

215. **Hydraulically disconnected streams:** If a stream is separated from the groundwater table by an unsaturated zone, it is a hydraulically "disconnected" system. In disconnected systems, although groundwater pumping does not affect streams, streams do affect groundwater through streambed seepage that recharges the groundwater system. Groundwater systems are often disconnected from the streams in arid regions and in regions where groundwater pumping has significantly lowered groundwater levels.

216. **Fertilizer and pesticide run off and drainage in rivers:** A uniform issue among rivers that receive fertilizers and pesticides in moderate to high quantities is the high BOD and COD in surface water and the high concentration of nitrates, chlorides, fluorides etc., in the ground water.

217. **Domestic and Industrial waste water:** This results in high BOD levels as well as high bacteriological and coliform (fecal and total) levels in surface water. Ground water reflects the issue with increased TDS, pH, nitrates, chlorides and fluorides.

### 3.9.1 Types of Groundwater Contamination

218. Groundwater pollution caused by human activities usually falls into one of two categories: point-source pollution and nonpoint-source pollution.

219. Fertilizers and pesticides applied to crops eventually may reach underlying aquifers, particularly if the aquifer is shallow and not "protected" by an overlying layer of low permeability material, such as clay. Drinking-water wells located close to cropland sometimes are contaminated by these agricultural chemicals.

220. Point-source pollution refers to contamination originating from a single tank, disposal site, or facility. Industrial waste disposal sites, accidental spills, leaking gasoline storage tanks, and dumps or

landfills are examples of point sources. Chemicals used in agriculture, such as fertilizers, pesticides, and herbicides are examples of nonpoint-source pollution because they are spread out across wide areas. Similarly, runoff from urban areas is a nonpoint source of pollution.

221. Because nonpoint-source substances are used over large areas, they collectively can have a larger impact on the general quality of water in an aquifer than do point sources, particularly when these chemicals are used in areas that overlie aquifers that are vulnerable to pollution. If impacts from individual pollution sources such as septic system drain fields occur over large enough areas, they are often collectively treated as a nonpoint source of pollution.

222. Natural Substances: Some groundwater pollution occurs naturally. The toxic metal arsenic, for instance, is commonly found in the sediments or rock of the western United States, and can be present in groundwater at concentrations that exceed safe levels for drinking water. Radon gas is a radioactive product of the decay of naturally occurring uranium in the Earth's crust. Groundwater entering a house through a home water-supply system might release radon indoors where it could be breathed.

223. Petroleum-based Fuels: One of the best known classes of groundwater contaminants includes petroleum-based fuels such as gasoline and diesel. Gasoline consists of a mixture of various hydrocarbons (chemicals made up of carbon and hydrogen atoms) that evaporate easily, dissolve to some extent in water, and often are toxic. Benzene, a common component of gasoline, is considered to cause cancer in humans, whereas other gasoline components, such as toluene, ethylbenzene, and xylene, are not believed to cause cancer in humans but may be toxic in other ways. One interesting property of gasoline is that it is less dense than water, and so it tends to float on top of the water table.

224. Aquifers in industrialized areas are at significant risk of being contaminated by chemicals and petroleum products. In most developed countries, various laws attempt to prevent land and water pollution, and to clean up contaminated areas when they occur. Developing countries and countries in economic distress are less likely than developed nations to assess the risk of groundwater contamination by land-use activities.

225. Chlorinated Solvents: Another common class of groundwater contaminants includes chemicals known as chlorinated solvents. One example of a chlorinated solvent is dry-cleaning fluid, also known as perchloroethylene. These chemicals are similar to petroleum hydrocarbons in that they are made up of carbon and hydrogen atoms, but the molecules also have chlorine atoms in their structure.

226. As a general rule, the chlorine present in chlorinated solvents makes this class of compounds more toxic than fuels. Unlike petroleum-based fuels, solvents are usually heavier than water, and thus tend to sink to the bottoms of aquifers. This makes solvent-contaminated aquifers much more difficult to clean up than those contaminated by fuels.

### **3.10 Degradation of aquatic ecosystems and impacts on livelihoods**

#### **3.10.1 Impacts of development on the river ecosystems and subsequent mitigation measures**

227. Since independence, India has witnessed rapid urbanization, industrialization, and intensification of agriculture, which all affected the rivers in different ways. Most Indian rivers, at present, are highly regulated. Hundreds of multi-purpose reservoirs for water supply, irrigation, hydropower and fisheries have been constructed, as well as numerous barrages for water diversion. Many floodplains have been cut out from rivers by embankments and remaining riparian lands are under intensive agriculture and grazing pressure.

228. Over the 6<sup>th</sup> and 7<sup>th</sup> five year plans, water resource management was developed by increasing the responsibilities of the central ground water board to act upon implementation of schemes rather than merely be a data provider. And the genesis of a national view to extract maximum benefit of the available water vis-a-vis agriculture, irrigation systems and technocratic solutions. The impacts of this on the aquatic

ecosystems and their quality degradation were not understood by planners and not voiced effectively by the scientific community, and so they were not factored into water resource planning in any structured way, if at all.

229. The government and affiliated organizations were focused on supplying water, and the sustainability of the nation's rivers and ground water tables wasn't a priority. As a result, through damming, and diversion of water, some rivers have changed from perennial to seasonal, some from ephemeral to perennial and most have lost parts of their flow regime essential for maintaining them in good condition. The water that remains in the ecosystems has in many cases been becoming increasingly polluted.

230. Human settlements, deforestation, mining and other activities have degraded the river catchments and increased sediment loads of all rivers. Also, during the past few decades, rivers have received increasingly large discharges of industrial effluents, fertilizers and pesticides from agricultural practices and domestic wastes (CPCB 1996). All this affected riverine biota. Species composition has changed and many species have nearly disappeared. The loss of feeding and breeding habitats in the floodplain water bodies due to the construction of embankments, and increased silt load and macrophytic growth are major causes for declining fish resources.

231. Many valued plant and animal species have been reduced in abundance or have disappeared altogether, while some have been transferred through inter-basin transfer schemes to parts of the country where they did not historically occur, perhaps to become pest species in their new locations. Other economic impacts of degrading rivers have become increasingly obvious. Environmental degradation costs India about \$80bn a year, nearly 6 per cent of gross domestic product, according to a World Bank study.

232. After independence, the Government of India (GoI) has steered the country's water resources rather aggressively, resulting in the present scenario, where the scope for surface and groundwater sources expansion has stagnated. Thus, the challenge for India now lies in the efficient and effective management of existing water resources via a sensible mix of decentralised responsibilities and authority to local institutions and also providing large-scale investment to redirect the surplus water to water deficit areas.

233. The first major initiative in the country was the Accelerated Rural Water Supply Program (ARWSP), which commenced in the year 1972-73. To provide impetus to the coverage, a Technology Mission on Drinking Water was subsequently launched in 1986. This mission was renamed the Rajiv Gandhi National Drinking Water Mission in 1991-92. In the year 1999, the Department of Drinking Water Supply (DDWS) was formed under the Ministry of Rural Development (MoRD), the main objective of which was focused on drinking water and sanitation.

234. It is symptomatic that out of the 30 world river basins marked as global level priorities for the protection of aquatic biodiversity nine (9) are from India due to their extensive and continuing development. These basins include Cauvery, Ganges-Brahmaputra, Godavari, Indus, Krishna, Mahanadi, Narmada, Pennar and Tapi. With an exception of Ganges-Brahmaputra, all the above basins have also been categorized as "strongly affected" by flow fragmentation and regulation. Conservation and restoration of rivers have become vital for the overall sustainable development of the country.

235. The IWMP is an initiative of the Department of Land Resources (DoLR) of the MoRD. Other ministries like the MoA and MoEF are also involved. Till April 2008, DoLR was implementing three watershed programs, viz. Integrated Wastelands Development Program, Drought Prone Areas Program, and Desert Development Program. Subsequently, during the Eleventh Plan (2007-12), all these programs were brought under a single entity, the IWMP, which is implemented under the Common Guidelines on Watershed Development, 2008.

236. The aim of the program is towards restoration of the ecological balance through harnessing, conserving and developing degraded natural resources like soil, vegetative cover and water (DoLR, n.d). Up to the Tenth Five Year plan (2002-7), it has been reported that nearly 51 Mha on watershed basis has been developed. DoLR is committed to updating scheme guidelines with periodic inputs from varied

institutions including research organisations, voluntary organisations, technical committees, workshops and seminars (ibid.). The modified IWMP (2008 onwards) has adopted a three-tier approach—the upper topography, which is largely hilly and forested, treated with support of the forest department. For slopes, which form part of the intermediate topography and are situated above agricultural land, IWMP would address all issues concerning land treatment by implementing best possible options, including cropping patterns, horticulture and agro-forestry. In the lower tier, consisting of plains and agricultural lands, the IWMP would be integrated with employment generating programs such as the National Rural Employment Guarantee Scheme (NREGS).

237. However, until recently, this “conservation” has been limited to “cleaning” of rivers by treatment of wastewater, occasional symbolic removal of garbage and enforcing the treatment of industrial effluents. So far, these efforts have not resulted in major improvements. Overall, there has been limited appreciation of the nature of rivers as ecosystems whose ecological integrity depends upon their physical, chemical, biological characteristics and interactions with their catchment.

### 3.10.2 Impacts of water resource development on livelihoods

238. A sustainable livelihood perspective provides an opportunity to stand back and explore how Watershed Development (WSD) affects the livelihoods of the poor, and to see how these impacts can be enhanced. In terms of the overall impact of WSD – as a means to rural poverty reduction – watershed-based approaches have been demonstrated to lead to substantial improvements in rural livelihoods. However, they are not a panacea: productivity gains in pilot projects have not been achieved to the same extent on a wide scale and the links between productivity gains and livelihoods is complex and poorly understood.

239. Of most concern, is that achieving these productivity gains can actually work against the livelihood strategies of certain groups. For instance restricting access to Common Pool Resources to improve grassland productivity denies the poor access to a valuable resource. Shifts to cash cropping, possible as a result of improved access to irrigation, can encourage a more risky livelihood strategy and lead to increased food insecurity at the household level. Undoubtedly, to achieve distributional equity is the most difficult challenge. An adequate distribution of benefits (poor/better-off; men/women) relies on exceptionally careful and continuing vigilance.

240. More thought is needed on development pathways appropriate for those areas where preconditions do not favour WSD. For example, seasonal migration is an important livelihood strategy for semi-arid India. Efforts to make the process less exploitative and support it through the public sector, via interested NGOs and/or via support through the banking system are likely to generate substantial poverty impact. By contrast, the evidence on alternative economic opportunities which are not land-based is mixed. NGO studies are filled with examples of how poor groups have succeeded in producing and marketing products made from Non Timber Forest Products, such as tendu-leaf plates, or in launching new enterprises such as beekeeping or silk production. However, these rarely consider the costs of providing financial capital and the necessary skills, and of underwriting the high level of risk. Where these are taken into account, the prospects for micro-enterprise appear much weaker

## 3.11 State of Pesticide use in India

241. The recommendations made for pesticides in India are unsatisfactory at multiple levels. There is lack of uniformity in the recommendations made by the Central Insecticide Board and other institutions. Therefore, it is difficult to either set the MRLs (Maximum residue limit) of a pesticide for appropriate food commodities or to monitor pesticide residues. The MRLs which have been set are in many cases very high and lead to TMDIs (Theoretical Maximum Daily Intake) exceeding ADIs (Acceptable Daily Intake).

242. The practices being followed by the farmers are not according to the recommendations. Farmers are mostly unaware of the technicalities of the pesticides and follow the instructions of the pesticide dealers. The dealers were, in few cases, aware of the CIBRC recommendations but in most cases ignored it. The State Agricultural Universities do not consider the recommendations of CIBRC while recommending pesticides. They have their own research mechanism that they follow. This leads to the difference between recommendations and makes it difficult to monitor the pesticides residues in crops.

243. The recommendations made by the Joint Parliamentary Committee have not been completely followed. The MRLs of many chemical pesticides have not been set. The recommendations included setting of MRLs for all pesticides for the crops they were registered for. However, the MRLs set do not cover the range of recommendations made for pesticides. MRLs of the pesticides for which TMDI exceeded ADI had to be revised. But the MRLs have not been revised and they are yet very high for a number of pesticides. Consequently, TMDIs exceed the ADI very frequently.

244. The MRLs need to be completed for all pesticides and for all crops the pesticides have been recommended for. The MRLs for some commodities like fruits and vegetables need to be revised and brought down to a level at which the TMDIs do not exceed ADIs.

### **3.12 Water Pollution, Sanitation and Health**

245. Water and health are intricately related. Unsafe water and poor sanitation contributed 7.5 per cent of total deaths and 9.4 per cent of total disability adjusted Life years. One third of all deaths of all children under five years of age in India are due to diarrhoea and pneumonia. Many more children who survive have weakened immune system because of diarrhoea, pneumonia, malaria, and worm infestations, and become underweight and malnourished which has a severe impact on their learning ability throughout their lives.

246. Water and sanitation are key barriers to prevent this, including safe excreta exposure and safe and adequate water supply coupled with good hygienic practices. While access to improved drinking water sources in India has increased over the past decade, the tremendous adverse impact of unsafe water on health continues.

247. The health impact of chemical contaminants in water is also responsible for disease burden, especially due to poor sanitation and hygiene practices. Infectious diseases linked to water can be categorized as waterborne, water-related, and water-based and water-washed diseases.

248. These pathogenic organisms are transmitted mostly due to contaminated water, improper sanitation and poor hygiene practices exacerbated by large volumes of untreated sewage generated daily in major cities. In the rural areas, due to the widespread practice of open defecation (69 per cent of the rural population) and poor operation and maintenance of water sources, microbial contamination occurs in surface and groundwater bodies. Also, approximately 74 per cent of the rural population does not use any water disinfection method. Research shows that India loses 90 million days a year due to waterborne diseases. Poor health due to inadequate sanitation is also an economic burden.

249. A study conducted by the Water and Sanitation Program (WSP) estimates that inadequate sanitation causes India 'considerable economic losses' each year equivalent to 6.4 per cent of India's GDP in 2006, that is, US\$53.8 billion (WSP, 2010). It is noteworthy that the total economic loss due to inadequate sanitation in 2006 was equivalent to state income of Tamil Nadu.

250. Out of the total US\$53.8 billion about US\$ 38.5 billion (Rs. 1.75 trillion) is lost due to health-related impacts. It is also known that children and poor households bear the brunt of poor sanitation. More than three fourths of the premature mortality-related economic losses are due to deaths and diseases in children younger than five. Diarrhea among these children accounts for over 47 per cent (US\$18 billion) of the total health-related economic impacts.

251. There is legislation in India that addresses the prevention and control of pollution—for example, the Water Prevention and Control of Pollution) Act of 1974, Water Cess Act of 1977 (amended in 1988 as the Water (Prevention and Control of Pollution Cess Act), and the umbrella legislation, the Environment (Protection) Act or EPA (1986). Recently, the Right to Information (RTI) has also been used by activists and people as a potent legislation to deal with discrepancies in the water sector. Although the Indian government is working more proactively on the increasing threat of water pollution, it will take far more than political will for these actions to translate into concrete measures resulting in improved water quality.

252. The water quality of river Ganga is being monitored since 1986 from Rishikesh in Uttaranchal to Uluberia in West Bengal by institutions such as Pollution Control Research Institute (Hardwar), CPCB Zonal Office Lucknow, Indian Institute of Technology, Kanpur, Patna University and Bidhan Chandra Krishi Vishwavidyalaya, Kalyani. As a result of the projects completed under Ganga Action Plan, the water quality of river Ganga has shown a general improvement despite tremendous population growth along the river banks as compared to pre-GAP period. Water quality monitoring carried out by reputed institutions such as, IIT, Kanpur, BHEL, Patna University, etc. indicates that, water quality of the river Ganga conforms to the prescribed standards in terms of key indicators, namely, Bio-chemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) at most of the locations, except in the stretch between Kannauj and Varanasi in Uttar Pradesh.

253. The level of bacterial contamination in terms of fecal coliform however, exceeds the maximum permissible limit at most monitoring stations along the river. The summer average values of two important river water quality parameters viz. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) recorded in some of the important monitoring stations on river Ganga. A very significant factor is increasing demand due to large scale water extraction for various purposes including irrigation, drinking water supply, and power projects. Besides this, inadequate operation and maintenance (O&M) by the States, underutilization of the STPs in some instances, delay in acquisition of land, contractual issues, court cases, erratic power supply and inadequate capacities of local bodies/agencies and lack of involvement of civil society were some of the constraints faced in the implementation of the Ganga Action Plan. The pollution load on rivers has increased over the years due to rapid urbanization and industrialization.

254. Domestic sewage is the major source of pollution of rivers besides industrial and other non-point sources of pollution. The water quality monitoring has also been undertaken for rivers namely, Yamuna, Western Yamuna Canal, Gomti, Hindon, Satluj (Punjab), Cauvery (Tamil Nadu), Tunga, Bhadra, Tungbhadra in Karnataka and Waterways of Chennai. The number of monitoring stations presently are 158 in 10 rivers which include 27 stations set up in the upper reaches of Ganga and 32 stations of Chennai Waterways.

### 3.13 Budget earmarked for Water Quality Issues in the Project

255. The total budget earmarked for water quality related issues in the project is Rs.85.54 crores. These are allocated in the following ways.

256. **Construction / furnishing / renovation of Water Quality Laboratories** - Rs 1574 Lakh (within Component A). These include construction of new water quality laboratories, renovation and/or furnishing of old water quality laboratories, up gradation of existing water quality laboratories from Level 1 to level 2 or from Level 2 to Level 2-plus.

257. **Equipment for water quality laboratories** – 3140 Lakh (within Component A). These will include equipment required for water quality laboratories such as samplers; various field kits; equipment for measuring heavy metals like Arsenic; UV spectrophotometer; atomic adsorption electro-photometer; autoclaves and digital balances.

258. **Automatic Water Quality Equipment** – 3120 Lakh (within Component A). These will include automatic equipment for in-situ measurements. In most cases, these equipment would be handheld, to be carried along to field and take readings. The parameters to be measured by such equipment would include physical parameters including EC, TDS, Water Temperature, Color, pH, Dissolved Oxygen, etc. In a few cases, the automatic equipment would be continuous monitoring equipment with telemetry options. Continuous automatic monitoring would also be mainly for monitoring and testing physical parameters mentioned above.

259. Table 3.3 is a list of parameters to be covered under the water quality monitoring activities in the project. The Table indicates where the tests/monitoring would be in-situ, or at the water quality laboratories, or where initial screening would be in-situ followed up by detailed analyses at the water quality laboratories.

**Table 3.3: Scope of Water Quality Monitoring in the Project**

Type	Parameter	Lab Instrument	Location	Continuous Monitoring	Field or Lab	Specific Scope
Cations	Lead	Atomic Absorption Spectrophotometer & Graphite Furnace	Initial screening in-situ + detailed analysis in Lab. Portable Colorimeter		Lab / Field	
	Arsenic	Atomic Absorption Spectrophotometer & Graphite Furnace, Digital Arsenator Arsenic Test Kit	Initial screening in-situ + detailed analysis in Lab			
	Zinc	Atomic Absorption Photometer	<b>Laboratory:</b>			Generally for SW and waste water
	Ni	Atomic Absorption Photometer	<b>Laboratory:</b>			Generally for SW and waste water
	Cobalt	Atomic Absorption Photometer	<b>Laboratory:</b>			Generally for SW and waste water
	Potassium	Flame Photometer	<b>Laboratory:</b>			
	Hexavalent Chromium	UV Spectro Photometer, Portable Colorimeter	<b>Laboratory:</b>			
	Mg					
	Iron	UV Spectrophotometer, iron test KIT	Initial screening in-situ + detailed analysis in Lab			
	Mn	Portable colorimeter	<b>Laboratory:</b>			

Type	Parameter	Lab Instrument	Location	Continuous Monitoring	Field or Lab	Specific Scope
	Boron	Atomic Absorption Photometer,	<b>Laboratory:</b>			
	Na	Flame Photometer	<b>Laboratory:</b>			
	Hg	Atomic Absorption Photometer,	<b>Laboratory:</b>			
	Se	Atomic Absorption Photometer,	<b>Laboratory:</b>			
Anions	Cl	Titration	<b>Laboratory:</b> Portable colorimeter			
	HCO3	Titration	<b>Laboratory:</b>			
	CO3	Titration	<b>Laboratory:</b>			
	SO4	UV Spectrophotometer, Portable Colorimeter	<b>Laboratory:</b>			
	PO4	UV Spectrophotometer, Portable Colorimeter	<b>Laboratory:</b>			
	F	Ion Meter with Specific Probe, UV Photo spectrometer	Initial screening in-situ + detailed analysis in Lab. Portable colorimeter		Field	
	NO3	UV Spectro Photometer	Initial screening in-situ + detailed analysis in Lab. Portable colorimeter		Lab	
Physical	pH	Digital pH, Multi parameters Water Test KIT	<b>In-situ</b>			
	EC/Salinity/ TDS	Digital Conductivity meter	<b>In-situ</b> : Multi parameters Water Test KIT	Need EC and Temp for Salinity, continuous monitoring for some sites		
	TDS	Digital Conductivity meter	<b>In-situ</b> : Multi parameters Water Test KIT			
	BOD	Lab only, BoD Incubator	<b>Laboratory:</b>			

Type	Parameter	Lab Instrument	Location	Continuous Monitoring	Field or Lab	Specific Scope
	COD	UV Spectrophotometer, COD reactor	<b>Laboratory:</b>		Not have now	
	DO	Not in LAB	<b>In-situ :</b> Multi parameters Water Test KIT			
	Total Hardness	Titration	<b>Laboratory:</b>			
	Turbidity	Hand Held Turbidity Meter	<b>In-situ :</b> Hand Held Turbidity Meter			
Microbiological	E Coli	Colony Counter Laminar Flow	<b>Laboratory:</b>			
	Total Coliform		<b>Laboratory:</b>			

260. **Development and standardization of water quality standards, and accreditation of water quality laboratories** – 620 Lakh (within Component A). These would include the standardization of water quality monitoring procedures, quality check of data, and the process of accreditations of water quality laboratories across the country.

261. **Water Quality Database development and management** – 100 Lakhs (within Component B), will include development of standardized database, upgrading of e-WQS, digitization of old data, and maintaining the database in a single platform.

262. **Purpose-driven Studies on Water Quality** – 1700 Lakh (within Component C), will include a large number of purpose driven studies to address various local (state, basin/sub-basin-wide) water quality issues. Examples of such studies are: (a) detection of salt water intrusion in coastal areas, (b) identification of safe pumping limits to avoid sea water intrusion, (c) exchange of saline water and fresh water in salinity affected areas like southern Punjab, and (d) detection, tracing and quantifying areas with arsenic, fluoride contamination in West Bengal.

## 4 CHAPTER 4: ECOLOGICAL FLOWS & INTERVENTIONS

### 4.1 Background

263. Since independence, India has witnessed rapid urbanization, industrialization, and intensification of agriculture, which all affected the rivers in different ways. Most Indian rivers, at present, are regulated. Hundreds of multi-purpose reservoirs for water supply, irrigation, hydropower and fisheries have been constructed, as well as numerous barrages for water diversion. Many floodplains have been cut out from rivers by embankments and remaining riparian lands are under intensive agriculture and grazing pressure. Human settlements, deforestation, mining and other activities have degraded the river catchments and increased sediment loads of all rivers. Also, during the past few decades, rivers have received increasingly large discharges of industrial effluents, fertilizers and pesticides from agricultural practices and domestic wastes (CPCB, 1996). All this affected riverine biota. Species composition has changed and many species have nearly disappeared. The loss of feeding and breeding habitats in the floodplain water bodies due to the construction of embankments, and increased silt load and macrophytic growth are major causes for declining fish resources (Mukherjee 2005, Jhingran 1991). It is symptomatic that out of the 30 world river basins marked as global level priorities for the protection of aquatic biodiversity by Groombridge and Jenkins (1998), nine are from India. These basins include *Kavery*, *Ganga-Brahmaputra*, *Godavari*, *Indus*, *Krishna*, *Mahanadi*, *Narmada*, *Pennar* and *Tapi*. With an exception of *Ganga-Brahmaputra*, all the above basins have also been categorized as “strongly affected” by flow fragmentation and regulation (Nilsson et al. 2005).

### 4.2 Environmental Flow: Policy and Laws in India

264. There is no coherent policy or law in India with regard to freshwater flows in the rivers. Even the new National Water Policy still ranks “ecology” as the fourth item in the list of priorities for water-allocation. However, as the progressive degradation of the water environment became evident, environmental concerns have started to gain strength.

#### 4.2.1 Constitutional provisions:

265. The Constitution of India describes ‘water’ as a “state subject”. However, the allocation of ‘water’ to the state list is subject to qualification that powers of the state to own, manage and regulate “*Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power*” subject to a provision in the Union list (“entry 56”) that in public interest the Parliament of India can regulate and develop ‘inter-state’ rivers and river valleys. Overall, as most of the river basins in India are inter-state basins, the Union Government, if it desires, can enact to regulate the rivers, such that powers of the states on these rivers could be made limited in scope. However, states retain the powers to allocate use of water, and as such can mandate any environmental flow regime (as in the case of Himachal Pradesh, which mandated ‘lean flow’ requirements in the rivers of the state).

266. The *1992 amendments to the Constitution* devolved some water management powers to local governments. In the Eighth Schedule (Part IX) dealing with *Panchayats*, the subjects, “Minor irrigation, Water management and Watershed development”, “drinking water” and “maintenance of community assets” had been included. Similarly, in the Twelfth Schedule (Part IX A) dealing with municipalities, the subjects “water supply of domestic, industrial and commercial purposes” is listed. In principle, these local governments can stipulate regulations on water use, particularly for downstream flow requirement relevant to the subjects under their jurisdictions.

267. The Constitution of India describes “environment” as a fundamental right (in article 21, and in directive principles of the Constitution), a fundamental duty of the State or Union (article 48-A), and a fundamental duty of citizens (article 51-A). The High Courts and the Supreme Court of India, in a large

number of cases had recognized that these rights and duties are distinctly of fundamental nature, and therefore, supersedes most other provisions of law, in the event of conflicting interpretations. The description of “environment” is also judged to be inclusive, covering aspects from human health to right to dignified life to protection of natural and cultural resources. Based on such interpretation of the Constitution by the Supreme and High Courts, the Environment (Protection) Act, 1986 is seen to be an umbrella act, which overrides other acts (unless specifically exempted).

#### 4.2.2 Policy and Laws in the Hydropower Sector:

268. The major powers are derived from the *Indian Electricity Act, 2003*, and the *Hydropower Policy, 2006*. Under these, the Central Electricity Authority (CEA) is responsible to ensure that the projects are designed as per the relevant standards. CEA requires that the projects have environmental clearance, and complies with conditions of environmental clearances (which may include conditions related to environmental flows), and that requisite budget is provided for implementing environmental management actions before statutory approval of the project.

269. However, at strategic level, the Hydropower Policy does not provide any guidance on environmental flows. It merely requires that environmental laws be observed. Since the 2003 Hydropower Policy, no basin or state level hydropower planning exercise was undertaken (the plans implemented currently were prepared much earlier), and therefore it is not clear how the environmental flow issues will be covered in any new plan guided by the 2003 Policy.

#### 4.2.3 Policy and Laws in the Water Resources Sector:

270. The *National Water Policy (2002)* and most of the *State Water Policies* have recommended the maintenance of minimum flows in rivers. *The Tenth Five Year Plan* has also recommended the assessment and maintenance minimum flows in river systems. But these are non-binding recommendations. Further, environmental flow is lower priority in these policies compared to drinking water, irrigation and hydropower. In the event of multiple demand of water from the priority sectors identified in the policies, the established policy and practices tilt the decisions in such ways that environmental flows are almost always treated as a marginal issue, if not neglected.

#### 4.2.4 Policy and Laws in the Environment Sector:

271. Currently, most of the agenda on environmental flows are driven under the *National Environmental Policy 2005*, and the *Environment (Protection) Act, 1986*. The Environment (Protection) Act empowers the Ministry of Environment and Forests (MOEF) and the States to prevent environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country. This is an umbrella act in India and is used for environmental protection, conservation, futuristic regulations, for public purposes and to enforce public liability doctrine. Several notifications under the Environment Protection Act determines the acceptability of projects on a river, the most significant being the *Environmental Assessment Notification* (1994, revised 2006). Under this notification, the MOEF has the mandate to enforce environmental flows. Under this Notification, public hearings are conducted by State Pollution Control Boards, wherein if demanded by the local community, it is possible for the State Pollution control Boards to recommend environmental flow regime. Further, State Pollution Control Boards have powers under the *Water (Prevention and Control of Pollution) Act* (1974, amended 1988) to recommend environmental flows to prevent and control water pollution, and to maintain or restore wholesomeness of water in the river. Such recommendation could be guided by the Central pollution Control Board, which sets the standards for water quality. Note that CPCB has not set standards for environmental flows yet. Under the *Wildlife (Protection) Act* of 1972, the Wildlife Board of India can also stipulate environmental flows to protect or conserve aquatic wildlife in any downstream protected area.

272. Overall, the current policy coverage is described in **Table 1**. The current policy coverage, it may be noted is seen to be sector driven, and therefore, there are inherent conflicts among the policies, procedures and implementation with respect to the scope and meaning of environmental flows. There is currently no formal framework of river basin planning to resolve these conflicts, and arrive at solutions acceptable to all major stakeholders.

#### 4.2.5 Institutional Responsibilities:

273. The current institutional responsibilities are actual practices (which might differ from what is already provided in policy statements) are described in **Table 2**. The Table indicates that in the responsibilities are far from clear, which also suggests it is not clear who will have the primary role in future development of proper environmental flow norms and standards. It is possible that the institution which moves first (as in the case of the Department of Environment in Himachal Pradesh) will have a greater say in such matters. It must also be noted that there is vacuum at strategic planning level, some of which needs to be filled up in future by river basin level planning.

### 4.3 **Current Initiatives**

274. The issue of minimum flow became a public discourse in 1999, when the Supreme Court of India directed the government to ensure a minimum flow of 10 cubic meters per second in the Yamuna River as it flows through New Delhi for improving its water quality. However, as early as in 1992, the Central Water Commission (CWC) tentatively recommended that, as guidance, an average of 10 days of minimum flow should be conserved in rivers while planning for projects. In 1999, the Ministry of Water resources (MOWR) established the National Commission on Integrated Water Resources Development, which recommended that substantial studies are required to establish environmental flow regimes in the country, and recommended the overall water requirement for environmental conservation. None of the above recommendations were followed up in any noticeable way. As advised by MOWR, in 2001 the MOEF created the Water Quality Assessment Authority (WQAA) to help maintain good water quality and wholesomeness of rivers in India; and MOWR set up a separate wing within MOWR (called HP&MI Wing) to support the WQAA. The WQAA set up a working group in 2003 to advice on minimum flows in the rivers to conserve the ecosystems. The working group submitted its report in 2005. No follow-up action was taken. In 2002, the then new National Water Policy was adopted, which provided for allocation for environment. The follow-up State Water Policies also reiterated the position. However, the policies remained unenforceable due to lack of subsequent planning tools. In 2005, Himachal Pradesh announced a state policy to maintain 15% of the 'lean flow' as the minimum requirement for all projects. All new projects in Himachal Pradesh are expected to comply with this requirement (although in absence of critical monitoring infrastructure, the level of compliance is somewhat uncertain). Himachal Pradesh also required older project to comply, which the older projects protested and the case is pending in the Supreme Court of India. In parallel, Himachal Pradesh announced, in a first instance in the country, that the *Thirthan* River will be conserved in its natural state and no project will be allowed on this river.

275. MOWR has in the recent years trying to move towards a river basin planning approach. There had been no concrete advancement in view of the state-centre jurisdictional issues, but overall it has been recognized that optimum development of a river basin cannot be achieved without basin level planning covering all uses of water. If and when MOWR mandates basin planning to be the primary tool to allocate water uses and water resources development (replacing the current sector plans), environmental flows will be addressed in the basin plans, as the necessary generic guidance for preparation of any basin plan is already there.

276. In 2009, the GOI notified the National Ganga River Basin Authority (NGRBA) under the Environment Protection Act, 1986. The mandate of the NGRBA includes basin planning, and clearly talks about maintaining required flow in the river. In essence, the NGRBA (chaired by the Prime Minister) has all the powers to recommend environmental flow regimes for the rivers of the entire Ganga basin.

277. In absence of river basin plans, it is also possible that MOEF can unilaterally recommend particular 'minimum flow' requirements for projects that are subject to clearance under the Environmental Impact Assessment Notification (1994, revised 2006). In fact, in a number of hydropower projects in recent past, MOEF has directed projects to maintain specific 'minimum flow'. Such 'stipulated minimum flows' apparently have no sound analytical basis, and have satisfied neither the project proponents nor the environmentalists. It is also important to notice that such stipulation have been made for hydropower projects only (as far as known), whereas for many other projects creating similar impact on the river and the riparian areas, there were no such stipulations.

#### 4.4 Evolving Scenario

278. MOEF has started specifying 'minimum flow' requirements as a condition of environmental clearances for individual (hydropower) projects. In case of hydropower projects in Sikkim, MOEF had earlier mandated undertaking a carrying capacity study for the river basin. In the case of a major hydropower project in Arunachal Pradesh, MOEF had mandated an assessment of downstream flow issues. For almost all hydropower projects cleared by MOEF last two years, carrying capacity analysis has been stipulated with an aim that the projects will undertake to include mitigation measures in revised environmental plans. Currently, MOEF is interpreting that the environmental flow issues will be specifically covered within the scope of the carrying capacity analyses.

279. It is possible that the 2005 report of the working group of WQAA is brought back for wider discussion among experts and stakeholders. The scope of the working group (or some other form of the working group) might also be enlarged to study the issues in greater detail and provide specific recommendation to WQAA. The wing of MOWR created to support WQAA (dormant for a few years now) could be revitalized by MOWR who would not like to be left behind. Separately, the MOEF might ask CPCB to work towards bringing additional environmental flow norms under the Water Act.

280. The NGRBA is yet to be fully operationalized with adequate technical secretariat. Once the technical arms of the NGRBA are equipped, it is expected that NGRBA will take a major role in understanding and recommending environmental flow regimes for the rivers of the Ganga basin. As in the case of other such initiatives, once norms or standards are established by NGRBA (which covers 8 states) will be replicated by many other states. MOEF is also likely to follow NGRBA principles in or outside the Ganga basin. However, understanding the environmental flow scenarios for the Ganga basin will not be easy due to paucity of information on a number of aspects related to availability, use and use-efficiency of water resources. NGRBA had initiated an ambitious basin plan exercise (through a consortium of Indian Institute of Technology), but the basin plan exercise is nowhere near complete. It is likely that NGRBA will take a few more years to establish the environmental flow norms and standards.

281. The success of establishing NGRBA (and if this operates as intended) could be a major boost to MOWR, which has shied away from establishing inter-state river basin organizations for the past few decades (owing to the disputes among states, and between the Union Government and states). MOWR has recognized that river basin planning is essential to manage the water resources of India, and for the last few years is trying to create an atmosphere conducive to creation of river basin organizations. In a few years, it is highly probable that MOWR will be able to establish river basin organizations with adequate mandate, powers and technical skills to prepare basin plans. In such scenarios, environmental flow issues will be fully subsumed under river basin planning, and the issue of multiple turfs and authorities will be resolved.

282. Although the National Hydropower Policy does not specifically provide any significant reference to environmental flow, the Central Electrical Regulatory Commission (CERC) has a mandate to ascertain the reasonableness of hydropower projects and can appoint an independent agency to establish the same. The independent agency might assess the projects covering hydrology, geology, river basin level optimization, and the environmental impacts the project. CERC is in the process to bringing out guidelines

on capital cost and ceiling tariffs of projects. Both of these initiatives might include a reference to environmental flows.

283. Again a summary of the potential evolution of policy and strategies in near future, juxtaposed with the current policy coverage is described in **Table 1**. It may be seen that the initiatives are aimed at filling up the strategic gaps in the current policy coverage. At the same time, even if the policy on substantial environmental flows come into force (which is a distinct possibility, given the mandate the MOEF already has; and the increasingly popular demands for improved freshwater flow in rivers), at the level of project implementation substantial challenges will continue to remain in the absence of adequate river basin plans. Adequate river basin planning and plans are not expected soon due to the long history of disputes on river water; and the inherent issues of the division of responsibilities between the Union and the states.

#### 4.5 Knowledge Challenges for an Environmental Flow Regime

284. As noted earlier the Water Quality Assessment Authority (WQAA) was established in 2001, which in turn constituted, in 2003, a Working Group (WG) to advise the WQAA on 'minimum flows in rivers to conserve the ecosystem'. The WG reviewed the existing practice of assessment of environmental flows and suggested that due to a variety of reasons, including the high hydrological variability, difficult tradeoffs between environment and agriculture, expensive waste treatment, disputes for water between states, etc., the practices adopted in other countries for assessment of environmental flow are unlikely to be applicable in India. The WG also suggested that only a simple method may be adopted for estimating 'minimum flows' to be maintained in the rivers in India. These flows would primarily serve the purpose of maintaining prescribed water quality standards. Overall, the status of research with regard to environmental flow in India at present may be characterized as being in its infancy. The National Commission for Integrated Water Resource Development Plan (NCIWRDP, 1999) effectively accepted that it was not possible to estimate the amount of water needed for environmental purposes. They pointed out that the knowledge base for making any approximate calculation of this requirement was very limited.

285. Overall, for mandating specific environmental flow regimes, substantial investment in creation of information and knowledge is required. Until then, the recommended flow regimes, if any as in the case of Himachal Pradesh, would be unilateral, subject to disputes and interpretations of courts. A proper systematic application of environmental flow regime standards at the level of specific rivers, and its implementation at the level of individual projects does not seem feasible within the next few years. Until such knowledge base is developed, normative estimates of environmental flows will continue to be recommended, without much confidence to ascertain whether the estimated environmental flows are too low or too high.

#### 4.6 Role of Basin Planning in ensuring appropriate Environmental Flows

286. It is understood that environmental flow in the basin is beyond, and is not necessarily related to hydropower projects alone. Further, even in the cases of hydropower projects, it and is dependent upon many multi sectorial players in the basin. However, based on a general assessment of hydropower projects (which includes appraisal of several papers and unpublished literature by both proponents and opposition of stricter and expansive environmental flow regimes), the following are conceptual suggestions to mainstream environmental flow regime considerations in basin planning. These may have special applications in the upstream parts of the basins of the hydropower projects. These suggestions are limited to hydropower sector only, but if needed could be extrapolated and refined for all other projects which change the quality and quantity of the river flow.

- i. **Basin level planning and coordination in the basin is the key.** Generally, hydropower projects under development today reflect basin-level planning as it was practiced some decades ago, which did not take into account factors that today are considered essential to sustainable development, such as ensuring adequate environmental flows. Given that these cascades of

hydropower projects are sometimes owned by different developers, coordination in design and operation of plants in cascade is essential to maximize efficiency and to deal adequately with environmental impacts. With these in mind, one important step for achieving long-term objectives of hydropower development program is to restart a basin level planning process with objectives modified to reflect issues considered important by the society today.

- ii. **Use of regional planning tools to plan and prioritize basin level hydropower program.** A spatial orientation of the basin-level hydropower program is required, superimposing and integrating all other large-scale development projects and programs, as well as the environmental and ecological conservation programs and projects. This would mean using regional planning approaches to locate, rationalize and prioritize hydropower projects; and to internalize in the planning process itself the compensation for effects of the desired balance of hydropower projects versus conservation needs.
- iii. **Informed decision-making through improving baseline information availability and reliability needed.** Any decision for rationalization has to be based on improved knowledge and understanding of (i) operational coordination requirements of hydropower projects in a cascade, (ii) better understanding of the cumulative impacts on ecological resources, communities, and close alignment with social and cultural values, (iii) better understanding of the geological and geotechnical issues. It is important, therefore, to start an adequately funded detailed investigation program (ideally at the central level) for next 5-10 years, so as to be able to answer lingering uncertainties of knowledge.
- iv. **Initiate extensive capacity building and real-time monitoring programs.** Irrespective of the range of environmental flow regimes and other environmental conditions stipulated by regulation, there would be a need for monitoring compliance. Two aspects are important in this: the state level environmental regulators do not have adequate capacity (of resources, staff and skills); and the baseline to compare compliance performance is absent for most parameters. GOI may consider kick starting a capacity building program for the state level environmental regulators. The necessary complementary activity to be financed is a real-time monitoring system for important parameters (such as flow in the rivers, tributaries and rivulets at sufficient number of points; and the sediment load) and availability of this information in public domain.

287. The above requirements are imminent, but in the slightly longer term, further studies and research will be necessary. Some of these are already suggested by a number of expert institutions, such as the Indian Institute of Technology, Roorkey (IIT-R) and the Wildlife Institute of India (WII).

- i. Detailed (coordinated by a single agency) measurements of river discharge over the years, river cross sections, velocity of flow, sediment load for all rivers and tributaries;
- ii. Detailed geological studies to map geottracts, identification of problematic areas of earth mass failure, and applicability of measures to avoid saturation of earth mass;
- iii. Study of the accumulation of sediments upstream of the hydropower projects, and its stabilization;
- iv. For an adequate number of sampling sites (say, at every 20-30km, or more, at upstream of every important ecologically sensitive receptors) a detailed coordinated measurement of water quality parameters;
- v. Detailed inventory of rare, endangered and threatened flora and fauna, their habitats and associations;
- vi. Tracking survey of all important rare, endangered and threatened migratory species of fishes, and other keystone species of flora and fauna;

- vii. Aerial photography (or LiDAR survey) of the basins to develop a baseline of accurate physical characteristics such as forest cover, landform and land use, to be compared with sample aerial photography and satellite imageries every 3 or 5 years, and to be used in a geographic information system (GIS) for improved planning of the basins (and the catchment area treatment in particular);
- viii. Detailed mapping all valued ecosystem components (determined by wide consultation with communities and village elders);
- ix. Studies for preparation of basin-wide heritage conservation plans.

288. **Recommend appropriate institutional mechanism to coordinate and implement basin-wide and sector-wide actions** to facilitate optimum and effective development of hydropower. This could be achieved by specifying roles of expert institutions or centers of excellence to undertake the sector level detailed investigation programs and other research studies to address uncertainties as described in paragraph (e) above. One option could be a hub and spoke model, where relevant expert institutions take up specific work in their area of expertise, and central agency is given the responsibility to coordinate and synthesize outputs from each of these institutions on a continuous basis, and as such synthesis become the basis of the next round of work by the centers of excellence. This model of study, research, coordination and creation decision-support systems will be resource intensive, and it is important to ensure provision of sufficient assured funding for this (which might be available, say, from the possible use of the National Clean Energy Fund).

289. **Alternative ranges of environmental flows:** Using the recommendations from the report<sup>4</sup> of the Wildlife Institute of India, Dehradun (WII) for projects located in areas where the river is expected to have higher biodiversity values; and using those of the IIT-R Report<sup>5</sup> for projects located in river stretches with relatively lesser biodiversity values. This principle could be applied in two ways:

- i. All sub-basins determined to be “very high” or “high” in biodiversity values in the WII report could be considered to be of high biodiversity value; where WII recommendations can apply. For others, the IIT-R recommended values can apply. As the richness of fish diversity is probably a near-correct indicator of overall biodiversity richness, using the environmental flows recommended by the WII Report for the “mahaseer zone” and the “snow trout zone” of the rivers, and using IIT-R recommended environmental flows elsewhere.
- ii. All river stretches 2000m above MSL could be considered to be of lower biodiversity and richness values (as has been empirically determined for terrestrial ecosystems in other parts of the Himalayas) where the IIT-R recommended environmental flows could hold, and for all projects located below 2000m, the WII recommended environmental flows could hold good.
- iii. **Benefit-sharing mechanisms.** Sharing of benefits at the river basin level and over the life of the project ensure a stake of the communities in the project over long term rather than a one-

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<sup>4</sup> The GOI also requested the Wildlife Institute of India (WII) for studying environmental flow requirements for conservation of flora and fauna dependent on riverine habitats and floodplain; and to recommend ways of upstreaming biodiversity considerations in basin-wide planning of hydropower projects. This report was also completed in 2012.

<sup>5</sup> For assessing cumulative impacts and for determination of environmental flows, with respect to the planned hydropower development on the Bhagirathi and the Alaknanda (both major upstream tributaries of the Ganga), the GOI requested the Indian Institute of Technology, Roorkee to assess the cumulative impacts of the existing, the “under-construction” and the proposed hydropower projects on these sub-basins and to recommend limits for development of hydropower projects without risking stability of landforms and environment. This report was completed in 2012.

time compensation. For example, Himachal Pradesh has introduced a new revenue sharing mechanism that pays annuities by cash transfers to the local communities living in the villages in the project area during the life of the projects. This annuity is from the sale of additional 1% of power generation (over and above the “free power” and/or royalty to be paid to state government) where 85% is distributed among all project-affected families, and remaining 15% for additional cash transfers to Below Poverty Line (BPL) families. This system of cash transfers is over and above the infrastructure created by the local area development fund (LADF) from the 1.5% of the project cost paid by the project developers. While the approach adopted by Himachal Pradesh is on a project-to-project basis, similar approaches for benefit-sharing mechanism could be considered at basin level across all hydro endowed States.

**Table 1: Policy & Institutional Coverage for Environmental Flows in India: Current Scenarios and Possible Future Outlook**

POLICY SPAN		MAJOR INSTITUTIONAL PLAYERS			
Directives / Policy	Acts, Regulations, Plans	Central Government Level	State Government Level	Local Government Level	
Note: There is Overlap between Union and State Responsibilities	Constitutional Provisions	Management of water	MOWR	DOWR	-
	Five Year Plans	Hydropower Sector Plans	MOP	DOP	-
		Water Sector Plans	MOWR	DOWR	-
	National Hydropower Policy	Indian Electricity Act	MOP	DOP	-
			MOEF, Wildlife Board	State PCB, Fisheries Dep't	-
		State Hydropower Policy, if any	MOP	State Env, WR Dep't	-
		Standardization of capital cost & Tariff	CEA, CERC	SERC	-
	National Water Policy	Current Sets of Individual Projects	CWC	-	-
		Inter-Basin WR Plans	MOWR, MOP, MOEF	State Departments	Panchayat, Municipal Corporations
			NGRBA / Other Basin Agency	State PCB, Scientific Inst'n State Basin Agency	NGOs
	National Environment Policy	Environment Protection Act	MOEF	State EIAA, PCB	-
			National EP Authority	State EP Authority	-
			NGRBA / Other Basin Agency	State PCB, Scientific Inst'n State Basin Agency	Panchayat, Municipalities NGOs
		Water Act	CPCB	State PCB	-
		Wildlife Act	MOEF, Wildlife Board	State Env Dep't	-
Supreme Court Committee			State Forest Dep't	-	

Current Scenario – Clear Responsibility	Current Scenario – Partial Responsibility	Possible Future Responsibilities
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MOWR- Ministry of Water resources; DOWR – State Department of Water Resources/ Irrigation/Flood Control; MOP – Ministry of Power; DOP – State Department of Power; MOEF – Ministry of Environment and Forests; DOE- State Department of Environment; CERC – Central Electricity Regulatory Commission; SERC – State Electricity Regulatory Commission; CWC – Central Water Commission

**Table 2: Institutional responsibility & Practices in relation to Environmental Flows**

Source of Mandate		Institutional Responsibility and Actual role Played											
Level	Policy & Legal Framework	Strategic Planning			Design Norm + EIA			Project Design			M&E + Enforcement		
		MOP	MOWR	MOEF	MOP	MOWR	MOEF	MOP	MOWR	MOEF	MOP	MOWR	MOEF
NATIONAL	National Water Policy National Plans	CEA	CWC	-	CEA	CWC	CPCB	CEA	CWC	MOEF	CEA	DOWR	MOEF
					CERC		SPCB			CERC		CWC	SPCB
	Hydropower Policy, National Plans	CEA	-	-	CEA	CWC	MOEF	CEA	CWC	MOEF	DOP	-	MOEF
		CERC					CPCB			SPCB	SLDC		SPCB
	Environment Policy and Regulations	CEA	CWC	Wildlife Board	CEA	CWC	MOEF	CEA	CWC	MOEF	DOP	DOWR	MOEF
							CPCB			SPCB			SPCB,DOE
STATE	Water Policy & Plans	-	DOWR	-	-	-	DOE	-	DOWR	-	-	MOWR	MOEF
							CPCB						
	Hydro Policy & Plans	MOP	-	-	CEA	CWC	MOEF	CEA	CWC	SPCB	SERC	-	-
							CPPB						
	Env Regulation & Plan	-	-	DOE	-	-	DOE	-	-	SPCB	-	-	SPCB
				SPCB									
-	-	-	Wildlife Board	-	-	-	-	-	-	-	-	-	
			-										
LOCAL	Watershed Plan	-	-	-	-	-	-	-	-	-	-	-	Panchayat
	Hydro Projects	-	-	-	-	-	-	-	-	-	-	-	
	Env Regulation, Public Hearing	-	-	-	-	-	SPCB	-	-	-	-	-	SPCB

Strong & Primary Role	Secondary Role but with Regulatory Function	Secondary and Weak Role
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CPCB – Central Pollution Control Board; SPCB – State Pollution Control Board; CEA – Central Electricity Authority; SLDC – State Load Dispatch Centre; Wildlife Board – Wildlife Board of India

# 5 CHAPTER 5: BASIN PLANS & INCORPORATION OF ENVIRONMENTAL ISSUES

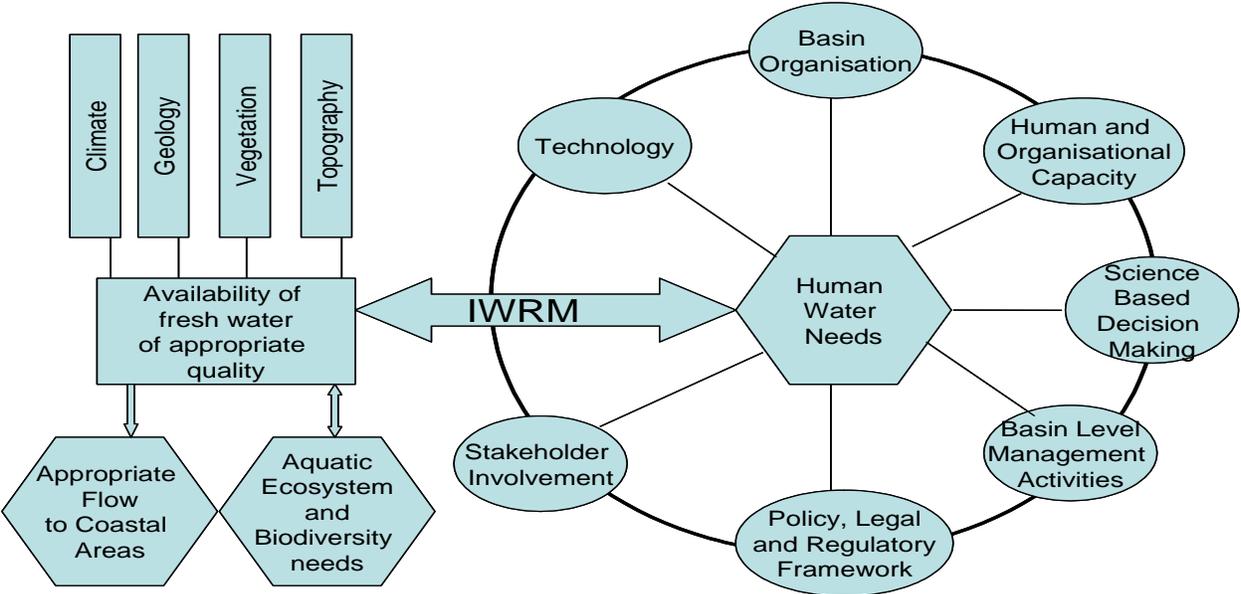
## 5.1 Background

290. The concept of Integrated Water Resources Management (IWRM) emerged around the 1980s in response to increasing pressures on water resources from competition amongst various users for a limited resource, the recognition of ecosystem requirements, pollution and the risk of declining water availability due to climate change. IWRM addresses the “three E’s”: Economic efficiency, Environmental sustainability and social Equity, including poverty reduction. The three basic “pillars” of IWRM are the *enabling environment* of appropriate policies and laws, the *institutional roles* and framework, and the *management instruments* for these institutions to apply on a daily basis. IWRM addresses both the management of water as a resource, and the framework for provision of water services to all categories of users, and it addresses both water quantity and quality. The basin/sub basin must be recognized as the basic unit for planning and management, and a firm societal commitment and proper public participation must be pursued. India has not yet reached the level of Water Resources Development as has already been achieved by many developed countries; therefore, there is a need for India to undertake developmental measures along with management measures

291. A central goal of IWRM at the river basin level is to achieve water security for all purposes, as well as manage risks while responding to, and mitigating disasters. The path towards water security requires trade-offs to maintain a proper balance between meeting various sectors’ needs, and establishing adaptable governance mechanisms to cope with evolving environmental, economical and social circumstances.

292. Well-developed, well-tested, scientifically robust, socially acceptable and economically viable approaches to implement IWRM at the river basin level are still not widely available. IWRM strives for effective and reliable delivery of water services by coordinating and balancing the various water-using sectors – this is an important part of sustainable water management.

293. Various components involving IWRM and their interaction with each other are represented in the figure below.



## 5.2 Definition of IWRM

294. The term ‘Integrated Water Resources Development and Management’, as used in these Guidelines, is referred to in the context of implementing IWRM for the provision of water services at the river basin level. IWRM is defined by the Global Water Partnership (GWP-2000) as ‘**A process which promotes the coordinated development and the management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems**’. It is a holistic approach that seeks to integrate the management of the physical environment within that of the broader socio-economic and political framework. The river basin approach seeks to focus on implementing IWRM principles on the basis of better coordination amongst operating and water management entities within a river basin, with a focus on allocating and delivering reliable water-dependent services in an equitable manner.

## 5.3 National Water Policy (2012) on IWRM

295. The National Water Policy-2012, in several provisions, has enumerated the integrated perspective of water resources planning, development and management. One of the basic principles of the policy is that planning, development and management of water resources need to be governed by common integrated perspective considering local, regional, State and national context, having an environmentally sound basis, keeping in view the human, social and economic needs.

296. The Policy under para 2.3 states that there is a need for comprehensive legislation for optimum development of inter- State rivers and river valleys to facilitate inter-State coordination ensuring scientific planning of land and water resources taking basin/sub-basin as unit with unified perspectives of water in all its forms (including precipitation, soil moisture, ground and surface water) and ensuring holistic and balanced development of both the catchment and the command areas. Such legislation needs, inter alia, to deal with and enable establishment of basin authorities, comprising party States, with appropriate powers to plan, manage and regulate utilization of water resource in the basins.

297. Highlighting the importance of integrated water resources management, the policy under para 12.4 states that Integrated Water Resources Management (IWRM) taking river basin / sub-basin as a unit should be the main principle for planning, development and management of water resources. The departments / organizations at Centre / State Governments levels should be restructured and made multi-disciplinary accordingly.

## 5.4 IWRM – AN EVOLUTIONARY PROCESS AT RIVER BASIN LEVEL

### 5.4.1 Embarking on IWRM in a Basin

298. A country’s need for water resource management varies according to its characteristics –its geography, climate, size, population, political and cultural systems, level of development, and the nature of its water resource problems. Within a country or a river basin, different areas have diverse water problems and challenges. Each country and river basin must chart its own vision and plans based on its unique situation. Constructing infrastructure that can meet the demands of multiple sectors while ensuring water for irrigation and functioning of ecosystem as well as preventing floods and droughts can be given as examples of an integrated approach. Basin activities such as development, land use and climate change, that may impact water resources and the hydrometeorological characteristics in the basin must also be considered, while taking into account the social and cultural implications of the river for the population residing in the basin. Part of an IWRM approach is to characterize the present situation and use this and other information to anticipate future changes.

#### 5.4.2 Important Conditions

299. A fully integrated approach to manage water in a basin may not be immediately possible. However, this does not prevent embarking on IWRM at the basin level. Various water-related sectors or users should be considered in a well-coordinated manner, highlighting the interactions among them, their activities and associated infrastructure.

300. The conditions listed below are important, but are not a set of necessary prerequisites for implementing IWRM. It aims to create sustainable water security within the present constraints and through improving conditions incrementally in each basin. Water managers should seek and recognize which conditions are essential to effective management, which cannot be readily instituted, and which can be developed wholly or partially over time to progressively move up the spiral.

#### 5.4.3 Basin Management Plan and Vision

301. IWRM at the river basin level is a continuous process working towards a basin development plan. A clear vision should specify the area as well as the level of safety to ensure project execution. The services, expected benefits and effects of each project should be clearly presented in line with various agreements and the appropriate balance of related sectors. Periodic reviews of progress and hydrological conditions are important to consider changes in national objectives and other plans managed by sectors not directly related to water issues.

302. The River Basin Master Plan shall, *inter-alia*, include

- (i) all the results of the analysis of the River Basin Characteristics
- (ii) a comprehensive review of the impact of anthropogenic interventions on the status of surface water and ground water, including an estimation of pollution, point as well as diffused, in water uses
- (iii) identification of protected areas, social and cultural flow needs and duration
- (iv) environmental needs
- (v) ground water and protected aquifers, if any
- (vi) a summary survey of existing pricing policies and an economic analysis
- (vii) a fair assessment of the effects of existing legislations
- (viii) an economic analysis for optimal allocation and the notional cost of deviation from optimal

#### 5.4.4 Participation and Coordination Mechanisms, Information Sharing and Exchange

303. ***Identify and involve stakeholders:*** Sustainable basin management, from planning to implementation and operations, requires well-coordinated mechanisms and frameworks for participation of different stakeholders, sectors and levels of administration. Participants who may be adversely impacted and/or socially marginalized may be stimulated to participate within a consensus-building strategy. Stakeholder involvement can be defined appropriately for local conditions and improved gradually, for example by setting up a committee, public hearings and workshops in the process of applying IWRM at the river basin level. Stakeholder's participation and its improvement require assistance from various people representing different sectors. The identification of key stakeholders can be facilitated through interviews and meetings.

304. ***Sustained relationship with stakeholders:*** Sustained relationships among stakeholders assure successful IWRM. Initial sharing of general basin-wide data and information, and further sharing of more specific information regarding proposed projects, programs and policies, will assist basin partners to more readily develop trust and respect for one another. Local communities have a wealth of historical

hydrological knowledge and information. Thus, relevant stakeholders can collaborate in the sharing of reliable information, appreciate the mutual requirements, and to promote collaborative efforts to resolve basin issues.

#### 5.4.5 Capacity Development

305. Water resource management requires a minimal level of capacity at all levels, including that of decentralized local governments. Functional community-level capacity builds resilience to hazards, and facilitates the use of knowledge and technologies, innovation and education, thereby creating a culture of safety and resilience at all levels. Local capacity development and training priorities should be expressed as a regional agenda, to enable many partners along the research-to-development continuum, and to form collaborations where consortia, alliances, networks, and individual organizations may all find their place to both fund and benefit from it. Regional training priorities are best expressed in terms of problems of water functions that need to be addressed locally but regional synergies are possible. Development of a community's ability to function in participatory processes is also an important part of capacity development. Consensus-building should be based on dialogue amongst stakeholders. Jargon free terminology should be used to facilitate comprehension by important stakeholders outside the water sector. Thus, each stakeholder group would have a comprehensive vision of basin issues.

#### 5.4.6 Well-defined Flexible and Enforceable Legal Frameworks and Regulation

306. To apply IWRM, it is necessary to assemble and review the full range of existing laws and regulations that apply to water-related activities and determine how existing legislation adapts or can be better adapted to accommodate sustainability and integration with regard to water resources management. The development of legal and regulatory frameworks, in light of current practices of existing law and if required, any repeal/suggestion/improvements of existing law, provides the best method for proactively addressing potential issues in implementing projects. Water legislation can clarify the entitlement and responsibilities of stakeholders and ensure sustainable use of the resource by presenting a balanced approach between resource development for socio-economic purposes, and the protection of water quality, ecosystems and other public welfare benefits. In the early stages this can be adequately achieved through water resources agencies, but with good coordination and linkages to other relevant agencies, including those at the national level. Ideally, one agency should be responsible for facilitating this process. This most often requires a paradigm shift in mindset, behaviour, and organisational design from 'development, implementation, control and coordination of the processes for facilitation of the IWRM process. This is achieved by persuading the organisations and agencies involved in the basin to contribute to IWRM objectives and by convincing decision-makers—in terms they understand—of the validity of their approach so as to gain recognition and the necessary resources.

#### 5.4.7 Water Allocation Plans

307. Water is a shared resource among various sectors – including water supply & sanitation, irrigation, industrial sectors, and hydropower generation – that relate individually to specific economic, social or environmental activities and that depend in whole or in part on water to fulfill their needs and roles. Water resources development coordinated among the various sectors and users is facilitated by the preparation of a master plan reflecting individual sector plans, and offering the most effective and efficient utilization of a basin's resource. Sectoral water allocation to the co-basin States should be periodically reviewed and revisited.

#### 5.4.8 Adequate Investment, Financial Stability and Sustainable Cost-recovery

308. Implementation of IWRM needs to be financially sustainable. Apart from the development and planning functions, adequate funding is required to improve managerial capacity and support research for technical and best practice advancement and for raising public awareness of water resources management

issues through media and education. Various combinations of government grants, public resources, user charges and taxes, donor funds, and a basin environmental trust fund can be considered as funding options. Many international financing institutions and other major donors have roles to play in encouraging and advocating greater transparency and public participation in regional planning and decision-making on developments, and to inform the public of their potential impacts.

309. **Funding and Cost recovery:** Funds can be raised through tariffs, transfers, the central government support or through external aid. Sustainable cost recovery should be promoted. It is essential to make the most of available resources, choose the most appropriate projects and carry them out at the lowest possible cost.

310. **Management and development:** Many developing countries have struggled to balance management and development of the resource. Long-term management should be considered when conceiving and implementing development of the resources and infra-structure in accordance with those factors relating to finance and stability.

#### 5.4.9 Good Knowledge of Natural Resources Present in the Basin

311. Adequate knowledge and information on the water resources inventory and human resources of the basin is desirable. In many basins, however, it may be necessary to embark on developing a water resources management plan with available data and information. Maintaining and accruing sound knowledge of the natural resources in the basin and to ensure that it is strongly supported by scientific knowledge and views. Further scientific studies, audits and investigations can be targeted at key areas for greatest improvement in resource management. Water Resource managers should therefore include scientists among their resources and strengthen linkages with them throughout their activities.

312. A well-defined water related data collection network including its quantity and quality are key to planning, development and management of water resources. In this regard, relevant national guidelines (IMD, CWC, BIS, CGWB, CPCB and coastal data) and international guidelines including that of WMO may be referred. CWC guideline on 'Preparation of River Basin Master Plan' provides a comprehensive list of various data required for preparation of Master Plan of river basins.

#### 5.4.10 Comprehensive Monitoring and Evaluation of the River Basin

313. Monitoring and evaluation are essential for ensuring that the current management practices in water resources is properly implemented and to identify the needs for adjusting management strategies. Effective monitoring requires accessible data, analytical tools and adequate information. For this regular evaluation of the strategies and their outcomes is necessary. The basic factors which can be used to assess basin condition include:

- i. The health or condition of the natural resources of the basin.
- ii. Changes in the basin.
- iii. The negative phenomena that are occurring or likely to occur and in which parts of the basin.
- iv. The key parameters to respond to global/local changes.
- v. Indicators to link the assessment findings to the goals.
- vi. Financial operations.
- vii. Economic benefits.
- viii. Internal indicators such as accountability, consultation on the costs of data collection, and budget limitations.

- ix. Such assessment should not only be done internally but in an open and transparent manner, with the findings widely publicized.

314. Keep water managers updated on the latest technology. Local and central water managers should be updated on the use of current and emerging technologies and models such as:

- i. Satellite monitoring systems being developed internationally, which aim to provide information for adaptation and mitigation for climate change, reducing damage from disasters caused by nature and human beings, improving water resource management through better understanding of the water cycle, and using satellite imageries for Land Use Land Cover (LULC) information.
- ii. Improvements in rainfall prediction methods connected with run-off models and information technologies. These would be useful in reducing damage in the basins affected by frequent flooding.
- iii. The evolving role of communication technologies such as mobile phones and internet, which can be powerful tools for transmitting data.
- iv. Remote control of water storage and delivery systems in the basin. This can enable optimized water supplies in basins affected by water scarcity.
- v. Developments of scientific models to augment and interpret data in data sparse environments.

#### 5.4.11 Political Will and Commitment

315. Political-will at all levels can help unite all stakeholders and move the process forward. It is needed especially if the resulting plan or arrangement would create or require changes in legal and institutional structures, or if controversies and conflicts among stakeholders exist. Generally a high level of political commitment exists in varying degrees outside the water sector. Political will is a potential engine of public awareness. However, there is a feedback process, as strong political will is also often motivated by public pressure to address high-profile issues. Water managers should focus on promoting correct understanding of the importance of water and the necessity for IWRM when dealing with the public, press, governments and politicians.

### **5.5 Role of River Basin Organisations**

316. RBOs are basin/sub basin level multi-disciplinary organizations comprising of various co-basin State governments and central government so as to promote integrated water resources development and management in the basin/sub-basin.

317. River Basin Organisations (RBOs) support the integrated and physical and technical management of water resources, and, if developed adequately, can respond to the growing competition for water among various State governments and among agricultural, industrial, domestic, and in-stream uses within the basins. RBOs can help recognize the environmental impacts of water uses and water development at the basin scale and can effectively take appropriate adaptation measure to climate change.

318. Without integrated river basin management through the RBOs, there would be interstate disputes and limited collaboration between departments related to water (irrigation, agriculture, industries and environment). Water related data and information would remain fragmented, consequently reducing the possibilities to conserve water. Given the limited possibilities to increase water supply or decrease demand, water resources would continue to move to those uses where the value of water is highest (e.g to industry rather than to irrigated agriculture) and water would continue to be allocated in an ad-hoc, suboptimal manner (from a social and environmental point of view). Broadly defined, RBOs offer a mechanism to

achieve such integrated management by providing the framework for water allocation following efficiency and equity principles and also for resolution of disputes between various stake holders.

319. Majority of the current river basin management organizations are for specific functions, such as flood planning or water resources construction, water allocation, water pollution mitigation, etc. The adopted approach is demand oriented and focuses on resolving specific problems in the river basin. The main functions of RBOs are given in the table below:

<b>Function</b>	<b>Definition</b>
Integration	Ensuring that the management of surface water, ground water, water quantity and quality and the environment are managed in an integrated way
Participation	Facilitating the participation of the community in river basin planning, and consideration of issues, policies, strategies and plans.
Plan	Formulation of medium to long term plans for managing and developing water resources in the basin
Construct facilities	Activities executed for the design and construction of hydraulic infrastructure
Maintain facilities	Activities executed to maintain the serviceability of the hydraulic infrastructure in the basin
Allocate water	Mechanisms and criteria by which water is apportioned among different use sectors, including the environment
Distribute water	Activities executed to ensure that allocated water reaches its point of use
Monitor and enforce water quality	Activities executed to monitor water pollution and salinity levels and ensure that they remain at or below accepted standards
Preparedness against water disasters	Flood and drought warning, prevention of floods, and development of emergency works, drought preparedness and coping mechanisms
Resolve conflicts	Provision of space or mechanisms for negotiation and litigation
Protect ecosystem	Priorities and actions to protect ecosystems, including awareness campaigns
Coordinate	Harmonization of policies and actions undertaken in the basin by state and non-state actors relevant to land and water management.

320. Beyond functional cooperation there is integrated approach to river basin management focusing on the river basin as a whole and try to resolve the existing hydrologic, ecologic and socioeconomic problems through holistic policies. The integrated approach is widely endorsed and promoted by international organizations as well as by NGOs and scientists though there are few examples of truly integrated RBOs.

321. The type of RBO for a Basin is a function of the political and institutional situation and overall objective of the organization. Much of this will be assigned in its charter assigned by government. Common types of RBO include: (i) consultative bodies including stakeholders from government and civil society who advise government on river basin management needs. Implementation is done by others. (ii) Planning and regulatory bodies which oversee development of policies and plans for the basin. The RBO would oversee water entitlements and annual water allocations; delivery of major water diversions from the river; monitor water conditions. It may own, oversee, and operate water regulatory structures. It would provide a

service as a bulk water (whole scale) water supplier for which it might recover costs but usually not supply water to end users. (iii) A large multi-purpose organization that as well as undertaking the services of model (ii) it would undertake revenue raising services such as hydropower operation, or irrigation water supply. In deciding these models it is relevant to consider separation of roles between different organizations in order to minimize conflict of interest. For example an RBO that also supplies water to one sector such as irrigation on a fee for service basis may have a conflict with supplying water to other users in water scarce seasons.

322. Depending upon the RBO model and its power and autonomy, the RBO secretariat that provides administrative and technical support could be supplied by the government water agency, or, where the RBO is a more autonomous body (types ii and iii), it would have its own secretariat.

## 5.6 Important Directions for IWRM

323. Water conservation in every sphere and increase in efficiency of water use in every activity should be overriding considerations in water resources development and management. The methods and means of water resources management need to be sustainable over time both from the point of view of development needs and environmental sustainability.

### 5.6.1 Water Availability and Requirements

324. The main considerations are:

- i. The work of refining the assessment of water resources of various basins using modern technology and to collect reliable data pertaining to observed flows, utilization from surface and ground water resources for various uses need to be undertaken at periodic intervals. There is also a need to develop uniform guidelines for assessing water resources potential and assessing water requirements for various uses.
- ii. Impact of change in climate processes e.g. meteorological cycles, day/night temperature variations etc. influencing rainfall and runoff, evapo-transpiration, crop water requirements etc. observed through General Circulation Models (GCM) / Global Climate Models will have to be suitably downscaled to work upon the likely problems and their best possible solutions in each River Basin.
- iii. Activities should also be focused on improvement of ground water estimation methodology and estimation of ground water withdrawals, based on a total hydrologic system balance. Problems of non-accounting or double counting of interactions and withdrawal of resources are to be properly dealt with.

### 5.6.2 Water Rights and Priorities

325. The main considerations are:

- i. Every individual has a right to a minimum quantity of potable water for essential health and hygiene and within easy reach of the household i.e., on the immediate public access road of the household.
- ii. The minimum quantity of potable water shall be prescribed by the appropriate authority after expert examination and public consultation. However, the minimum quantity of potable water shall not generally be less than 25 litres per capita per day. The minimum quantity may however be geographically referenced State-wise and region-wise to take into account the climatological factors.
- iii. Safe Water for drinking and sanitation should be considered as pre-emptive need, followed by high priority allocation for other basic domestic needs (including needs of animals),

achieving food security, supporting sustainable agriculture and minimum eco-system needs. Available water, after meeting the above needs, should be allocated in a manner to promote its conservation and efficient use.

### 5.6.3 Policy, Legal and Institutional Framework

326. The main considerations are:

- i. There is a need to evolve a National Framework Law as an umbrella statement of general principles governing the exercise of legislative and/or executive (or devolved) powers by the Centre, the States and the local governing bodies.
- ii. There is a need for comprehensive legislation for optimum development of inter-State rivers and river valleys to facilitate inter-State coordination ensuring scientific planning of land and water resources taking basin/sub-basin as unit with unified perspectives of water in all its forms (including precipitation, soil moisture, ground and surface water) and ensuring holistic and balanced development of both the catchment and the command areas.
- iii. Integrated Water Resources Management (IWRM) taking river basin / sub-basin as a unit should be the main principle for planning, development and management of water resources. The River Basin Authorities / organizations need to be established and the departments / organizations at Centre / State Governments levels should be restructured and made multi-disciplinary accordingly.
- iv. Appropriate institutional arrangements for each river basin should be developed to collect and collate all data on regular basis with regard to rainfall, river flows, area irrigated by crops and by source, utilizations for various uses by both surface and ground water and to publish water accounts on ten daily basis every year for each river basin with appropriate water budgets and water accounts based on the hydrologic balances. In addition, water budgeting and water accounting should be carried out for each aquifers.
- v. Appropriate institutional arrangements for each river basin should also be developed for monitoring water quality in both surface and ground waters.
- vi. State Governments need to expedite the Enactment and Implementation of the Bills for Ground Water Legislation and legislation for Participatory Irrigation Management.
- vii. The regulation of groundwater shall be in consonance with the principles of non-discrimination and equity, principle of subsidiary and shall conform to the constitutional provisions for decentralisation of powers and functions.
- viii. Above the field level and below the State level, water districts may be formed, as has been successfully done in many countries. The water district management should comprise of representatives of all types of water users and the local governments. Agriculture and drinking water supply interests would have special representation and they should also be empowered to take decisions. The composition of the water district bodies and the setting of hydrological boundaries for each water district and the frame work of regulation have to be devised by each State / Basin and incorporated in the irrigation law.
- ix. The CWC should be restructured into a statutory high powered inter disciplinary commission, in order to deal with policy and reforms, centre-State and interstate issues planning and project finalization, international aspects other than those that have to be retained with the Ministry.
- x. NWRC is a high level Centre-State political body which meets at regular intervals. It may take steps to constitute committees, groups and even appoint eminent persons as mediators/

facilitators so as to have sustained, serious discussions and negotiations to arrive at solutions.

- xi. The extraction of groundwater in any manner in any area shall be regulated through community based institutions with due regard to the hydro-geological and ecological characteristics and features of the aquifer as a whole. Such users and community based institutions will be empowered to take information based decisions based on aquifer information and extraction data shared with them.
- xii. For the above, the appropriate Government and local Authority shall keep all groundwater related information, such as, groundwater levels, water quality, local aquifer maps and groundwater utilization, in public domain.
- xiii. The old irrigation acts are based on a concept of a social contract which is not appropriate in the present times. Instead of legitimizing a top down hierarchical relationship, the new social contract has to legitimize relationship of coequals or partnership between the irrigation bureaucracy and the water users. The State Irrigation Acts should be farmer friendly.

#### 5.6.4 Project Planning, Implementation and Prioritization

327. The main considerations are:

- i. River basin or sub-basin shall be developed with unified perspectives of water and ensuring holistic and balanced development of both the catchment and the command areas, following the principle of integrated water resources management.
- ii. Optimal utilisation of waters within a river basin shall be ensured, with due regard to the reasonable present and future needs for life and livelihoods, appropriate economic activity, social justice and equity, and ecological sustainability.
- iii. There is need to make changes in approaches to project planning, particularly in respect of allocation of water among various uses, dependability and carry over related issues, conjunctive use of water, lift projects and viability criteria.
- iv. There is a need to lay down improved procedures of benefit cost analysis after considering all relevant aspects, such as technical, financial, economic, social and environmental.
- v. Considering the heavy economic loss due to delay in implementation of projects, all clearances, including environmental and investment clearances, be made time bound.
- vi. Processes for detailed appraisal, establishment of techno-economic viability, regular monitoring of physical and financial progress as well as of resettlement and rehabilitation and funding in accordance with project programming schedule, which are followed in the case of externally aided projects, should be adopted for all other projects.
- vii. The assistance for large projects may be deducted from the central assistance to a State and kept as a separate pool/ fund. Within a large project, funding could be earmarked for phases and sub-systems also.
- viii. For Central Assistance, it is necessary to assess minimum number of years to complete the project/ phase and provide funds for that period in a non-lapsable manner.
- ix. A project should be considered as having commenced, only after the issue of formal administrative and technical approval by the Government and after clearance by the Technical Advisory Committee. All expenditure incurred prior to this should be shown against investigation and preparation.

- x. Major projects should be broken into identifiable and meaning full phases/ sub systems/ components ‘completion’ should be considered for each such phase/ component. The irrigation component should be considered to have been completed, if 90 per cent of the physical progress is achieved and the status continues for one year and if at least 80 per cent of the estimated potential is created. The balance may be dealt with as separate scheme.
- xi. Efforts should be made to constitute Joint Corporations (Centre and States) for selected projects with an MOU and arrive at an Agreement for joint management.
- xii. For speedy completion of projects, efforts need to be made for substantial changes in the contractual procedures.
- xiii. Guidelines have to be applied at the level of the State Governments which is the most relevant level for making decision about the implementation of important projects. Prioritization cannot be a one-time exercise since there is a continuing addition to the stock of possible projects. The exercise should be done before each Five Year Plan.
- xiv. Prioritized major projects could be phased further into identifiable sub-systems for implementation. Phasing should be supported by specific financial outlays for better monitoring and financial discipline.
- xv. In the case of new projects, the project cost should cover escalation over the proposed construction period and the project should indicate both the basic cost and the estimated completion cost. The cash flow assumed in the Project Report should be got certified by the State finance and planning departments, to indicate the State Government’s commitment.
- xvi. In the absence of clear understanding as to when a project should be considered as having commenced and completed, it is necessary to lay down the criteria regarding these for all to adopt.
- xvii. CWC should concentrate on large projects and monitor them more closely. The approval and implementation of medium projects may be left to the States. It may be laid down that in all such cases, the State proposing the project shall notify it in the Gazette with full details of the parameters laid down by the CWC. If there are objections, within the prescribed period, they should be sorted out mutually or through the Basin Organisations.
- xviii. Realistic O&M costs/ ha should be worked out by each State on pilot representative systems by allotting adequate funds. These figures should be used for fixing of rates. However, in working out the cost, the ceiling rates on establishment charges should be followed.

## 5.7 Sectoral Issues with reference to IWRM

### 5.7.1 Domestic Use

328. The main considerations are:

- i. Ideally, water supply and waste water management schemes should be integrated and for this it is necessary that water supply programs are not taken up without simultaneous taking up of waste water management schemes.
- ii. Urban and rural domestic water supply should preferably be from surface water in conjunction with groundwater and rainwater. Where alternate supplies are available, a source with better reliability and quality needs to be assigned to domestic water supply.

Exchange of sources between uses, giving preference to domestic water supply should be possible. Also, reuse of urban water effluents from kitchens and bathrooms, after proper treatment, to flush toilets and other uses should be encouraged.

- iii. The artificial difference in quantities of water supplies for urban and rural sectors needs to be rationalized as flushing is not dependent upon the nature of habitation. Hence, water supply quantity may be seen more as a human development index and made uniform in rural and urban areas.
- iv. The appropriate Government and local Authority shall ensure that urban water supply and sewage treatment schemes are integrated and executed simultaneously with provision of sewerage charges included in the Water supply bills.
- v. The problem of drinking water in tribal areas are more acute, therefore, to provide accelerated coverage of drinking water to all habitats in tribal areas, an appropriate mechanism should be devised.
- vi. The norms adopted for satisfying the basic human needs of communities (both urban and rural) may be reviewed periodically.
- vii. The assigned target of 100% coverage in water supply can be achieved only if impediments like inadequacy of funds are removed and an autonomous system with economic viability is encouraged. The latter has a direct impact on the generation of funds for maintenance and development.
- viii. To reduce the gap between demand and supply, water conservation measures be accorded highest priority, especially in areas facing water quality and scarcity problems, with emphasis on recycling/ reuse of treated waste water.
- ix. Poor maintenance of the systems by the utilities results in leakage of costly treated waters. The discipline of maintenance should be instilled in the utilities and they should be held accountable for it. The importance of maintenance should also be impressed upon consumers, since considerable leakage and waste take place in households also.
- x. Improved low cost technologies have to be developed and adopted to save cost of construction and maintenance.
- xi. Public Awareness needs to be created for reducing water consumption. Women's participation is to be encouraged to the maximum as they are the one who are the primary and major users at domestic level.
- xii. Wherever feasible, artificial recharge and rain water harvesting have to be encouraged. Instead of looking only for new and distant sources of water supply or tapping fast depleting ground water, local bodies should lay emphasis on water harvesting also.
- xiii. Provided that implementation of rainwater harvesting should include scientific monitoring of parameters like hydrogeology, groundwater contamination, pollution and spring discharges.
- xiv. Water resources projects and services shall be managed with community participation. For improved service delivery on sustainable basis, the State Governments / urban local bodies may associate private sector in public private partnership mode with penalties for failure, under regulatory control on prices charged and service standards with full accountability to democratically elected local bodies.

### 5.7.2 Irrigation

329. The main considerations are:

- i. Integrated and coordinated development of surface water and groundwater resources and their conjunctive use should be envisaged right from the project planning stage and should form an integral part for optimum utilisation of water resources. Conjunctive use planning can also be implemented in existing commands by way of including it in the scheme for modernisation and improvement.
- ii. Over-exploitation of groundwater should be avoided, especially near the coast to prevent ingress of sea water into sweet water aquifers, while implementing the conjunctive use planning in the new projects / existing commands.
- iii. Demand management shall be given priority, especially through;
  - (i) Evolving an agricultural system which economizes on water use and maximizes value from water, and
  - (ii) Bringing in maximum efficiency in use of water and avoiding wastages.
- iv. Considerable saving in water can be achieved by adoption of sprinkler, drip /micro-sprinkler irrigation systems in water scarce areas, having conditions conducive to their application. For better water application efficiency, proper design of field application methods as well as new methods, like drip and sprinkler need, to be used.
- v. In planning of water saving projects, detailed water balance studies should be made to ensure that the water savings are real and do not affect downstream users depending on lost water such as ground water recharge etc. Real water savings may be achieved by reducing non-beneficial evapo-transpiration and losses of water to polluted water bodies/saline ground water.
- vi. Awareness should be raised among Agricultural Water users in a command area on economical use of precious water, land planning, integrated farming, crop diversification, harvesting, storage in scientific method and its marketing etc.
- vii. There is a need to provide training to farmers in Crop Alignment including diversification as per water availability to increase the productivity for each unit of water
- viii. There is a need to provide training and skill development of farmers in enhancing effective rainfall for crop production through various agronomic and mechanical measures like adoption of Resource Conservation Technologies, such as land Leveling, Terracing and contour farming, Mulching, Fertigation, water harvesting etc.
- ix. Planning and execution of all components of irrigation projects including command area development works shall be carried out in a pari-passu manner with concurrent monitoring of projects with a view to prevent time and cost over-runs.
- x. Project planning and management of water resources shall be on the basis of regional agro-climatic considerations taking into account possible future scenario (including climate change) after maximizing water use efficiency and benefits from the locally available water resources.
- xi. Since a number of major projects are continuing over the plan period, the costs are increasing and the benefits are delayed, it is essential that a detailed review and evaluation of the ongoing projects is done so that appropriate lessons may be drawn and remedial measures taken in subsequent Plans. Benchmarking for the projects should be given maximum importance for increasing the performance of existing and future projects.
- xii. There is a need for:
  - (i) instilling discipline in equitable distribution through WUAs participation.

- (ii) instilling discipline in adopting advisable and designed cropping pattern through intervention of Agriculture Extension Services of State Agriculture Deptt, and cooperative federations for bringing synergy between market forces and farmers and optimal use of water.
  - (iii) operation of canals / distribution network on demand based rather than supply based distribution.
  - (iv) fixing of water rates on volumetric supply and recovery of water charges through WUAs.
- xiii. The gap between potential created and its utilization should be reduced to the minimum. Use of satellite imageries should also be made for assessment of irrigated areas. Appropriate guidelines may be laid down for reporting the figures of potential created and the utilization achieved so that there is uniformity in the figures reported. The figures of the irrigation/water resources department and land use statistics should also be reconciled.
  - xiv. There is need for periodical reappraisal of ultimate irrigation potential, created irrigation potential and actual utilisation in irrigation, in order to take measures to accelerate the utilisation of the potential created and make improvements in utilisation.
  - xv. There is need to undertake State / Basin-wise assessment of waterlogged and salt affected areas irrigated command. The status of protected and reclaimed land should be reviewed in every five year plan.
  - xvi. In order that the area under water-logging does not increase, precautionary measures have to be taken. In areas affected by water-logging, remedial and ameliorative measures have to be undertaken.
  - xvii. There is a need for a paradigm shift in emphasis towards improving the performance of existing irrigated agriculture. Marginal changes in irrigation practices may not be enough to increase productivity. If growth in irrigated agriculture is to be achieved, efficiency of the existing systems needs to be enhanced and water, so saved, should be utilized to increase irrigation intensive farming practices improved with modern inputs and technologies. Operation and maintenance have to be substantially improved through participatory management.
  - xviii. Heavy subsidies in electricity consumed for agriculture have tended to encourage wasteful use of energy and also wasteful use of water. This has also encouraged farmers to overdraw water from deep aquifers, thus causing water quality deterioration in many areas. It is therefore, necessary to gradually reduce the subsidy on power for agriculture.
  - xix. Till a system of demand based supply of irrigation is achieved, State Governments should make efforts in introducing Warabandi system of rotational water supply.
  - xx. After each modernization project is completed, a performance review should be carried out to assess the benefits and costs. Such a review should be made for all modernization projects which have so far been completed. For new projects to be taken up under this program, technologies and reforms should be included as components of the projects.
  - xxi. Canal automation is a new technology, which is being introduced in some projects in our country. The performances require to be watched carefully and the modifications, if any, to be incorporated in the future canal automation project identified.
  - xxii. Re-use is an important method of managing drainage water. The options for re-use of drainage water would include direct use for irrigation, blending with canal water, cyclic or

rotational use, saline agriculture, forestry system and solar evaporators, aquaculture and use of saline water through salt tolerant crops.

- xxiii. Detailed studies are needed to evaluate the longevity and viability of minor irrigation schemes.
- xxiv. For field level works in the case of major projects, minor irrigation works, repairs of tanks and other works in rural areas, as much funds as possible should be generated through community involvement.

### 5.7.3 Flood Control and Management

330. The main considerations are:

- i. Dams have played a vital role in moderating the inflow flood peaks and also absorbing the floods. Adequate flood-cushion should be provided in water storage projects, wherever feasible, to facilitate better flood management. In highly flood prone areas, flood moderation should be given overriding consideration in reservoir regulation policy even at the cost of sacrificing some irrigation or power benefits. The rule curves should accordingly be devised for operation of reservoirs so as to get optimum benefits and such rule curves should be modified periodically taking the current flow data and considering the impact of climate change in the flow pattern.
- ii. In addition to structural measures, non-structural measures also need to be simultaneously taken e.g. efficient management of flood plains, flood risk mapping, flood-plain zoning, flood proofing including disaster preparedness & response planning, inflow forecast, flood forecasting & warning, and other non-structural measure such as disaster relief, flood fighting including public health measures, awareness raising and flood insurance. Although, it is feasible in most cases to provide a certain degree of protection against floods in terms of reduced frequency and flood damages, there are no universal solutions which can provide complete protection against floods.
- iii. Embankments/spurs do provide reasonable protection. The performance review of selected embankments/spurs may be carried out and based on the findings, planning, designs and management of embankments/spurs may be reviewed for obtaining better results. The embankments/spurs or any other such structures may also be examined through model study before execution. It is essential to associate the beneficiaries in the upkeep and surveillance of embankments/spurs during the monsoon season for prevention of possible breaching.
- iv. The appropriate Government and local Authority shall expand flood forecasting extensively across the country and modernize flood forecasting using real time data acquisition system linked to forecasting models.
- v. Operating procedures for reservoirs shall be evolved and implemented in such a manner to have flood cushion and to reduce trapping of sediment during flood season on the basis of sound decision support system.
- vi. Need for river mouths dredging for removal of the deposited silt as a part of flood management may be assessed periodically and implemented.
- vii. There should be proper coordination between the co-basin states during release of water from upstream states so as to manage flood effectively for the benefit of the inhabitants of the entire basin.
- viii. Possibility and feasibility to divert and store the flood water for later use may be explored.

#### 5.7.4 Hydropower

331. The main considerations are:

- i. There is an urgent need to evolve suitable strategies for accelerating the pace of hydropower development. In north-eastern region and Jammu and Kashmir where there is large hydro potential but the transmission costs to consuming center is high, energy intensive industries could be located close to the hydropower project sites. This would attract private participation and accelerate hydro-power development and also help in development of the region.
- ii. The other measures may be classified broadly in two parts; the first as a short term strategy and the second as a long term strategy. The short term measures include - full financial support to public sector on-going schemes, through survey and investigations and preparation of DPRs strictly in accordance with norms, effective monitoring, sorting out implementation problems where necessary, completion of renovation, modernization and uprating of old plants and small hydro development. The long term strategies include expediting the hydro potential review in consonance with environmental concerns, resolution of interstate disputes, promotion of joint ventures, tariff rationalization, R&R policy etc.
- iii. Unlike other water uses, the planning for power cannot usually be restricted to the demand within a basin alone. The demand for a region or the nation, as a whole, is important rather than demand in a basin. Therefore, the planning should attempt to generate hydroelectric power wherever feasible. The excess power, if any, can always be used elsewhere through regional grids.
- iv. All water resources projects, including hydro power projects, should be planned to the extent feasible as multi-purpose projects with provision of storage to derive maximum benefit from available topography and water resources.

#### 5.7.5 Industrial Use

332. The main considerations are:

- i. Actual quantity of water utilized by the major industry should be monitored by government agencies. Major water using industries and businesses consuming water more than one Million Cubic Meter in a year shall file annual 'Water returns' containing information, such as, water utilization per unit produce, effluent discharge details, rain water harvested, water reuse details and freshwater consumption.
- ii. Waste utilisation technologies/ clean production technologies with emphasis on waste minimization. Recycling and reuse of water, after treatments to specified standards, should be incentivised through a properly planned tariff system. .
- iii. Instead of allowing location of hazardous industries and insisting on Zero effluent condition in semi-arid and arid areas, industrial zoning be done in a manner that in such areas water intensive industries are not permitted especially those releasing toxic effluents. Even if allowed, such industries may be allowed to either withdraw only the makeup water or have an obligation to return treated effluent to a specified standard back to the hydrologic system.
- iv. Private sector participation would be practicable in projects mainly intended for supply for industrial use and urban water supply. The responsibility of the state as public trustee shall remain even if some of the functions of the state in relation to water are entrusted to any public or private agency.

- v. Hazardous waste treatment and disposal need to be so planned and executed so as to protect people and environment from adverse impacts.
- vi. Selection and zoning of industries associated with potential risks especially those releasing toxic waste, need a thorough analysis and planning before they are set up in any basin. The concerned State Government and other local bodies should have a coordinated approach in selecting and locating industries of a specific nature with respect to their water requirement and facilities for wastewater disposal. A policy for zoning the river basins according to the types of industries, quantity of water consumed, and effluent discharge need to be laid down.

#### 5.7.6 Navigation

333. The main considerations are:

- i. Development of inland water transport needs basic infrastructure like the fairway, terminals and navigational aids. State Government should undertake the development.
- ii. Water front development program and rebates for investments are necessary to bring traffic generating activity back to the rivers.

#### 5.7.7 Ecological and Other Uses

334. The main considerations are:

- i. The appropriate Government shall take all measures to protect the ecological integrity necessary to sustain ecosystems dependent on waters. A portion of river flows shall be kept aside to meet ecological needs ensuring that the low and high flow releases are proportional to the natural flow regime, including base flow contribution in the low flow season through regulated ground water use.
- ii. Outdoor activities are generally associated with the presence or proximity of water, particularly reservoirs. The water quality and maintenance of aesthetics around river or water body is very important for development of recreational activities.
- iii. Riparian rights of the inhabitants along the river sides should be preserved as prevailed from the ancient times.

#### 5.7.8 Special Ground Water Aspects

335. The main considerations are:

- i. The critical importance of the nexus between groundwater and the agricultural policy, urban infrastructure and energy consumption has to be stressed, since without integrated vision and action at these interfaces, the major challenge of groundwater-resource sustainability cannot be effectively addressed. The approach for groundwater management needs to be multidisciplinary and strongly participatory.
- ii. Ground water quality protection should follow a strategy comprising the systematic assessment of groundwater-pollution hazard (based on mapping of a aquifer-pollution vulnerability and subsurface contaminant loads) and definition of a 'groundwater protection plan'.
- iii. An interdisciplinary framework for planning groundwater management may consist of the
  - (a) Encouraging Local institutional arrangements with an empowered government agency facilitating community awareness and participation and, where appropriate, self regulation
  - (b) Financing and implementation of demand-side and supply-side measures.

- iv. Aquifers should be identified and mapped at micro level to quantify the available ground water resources and make plans appropriate to the scale of demands and aquifer characteristic.
- v. Artificial recharge of ground water is one of the most efficient ground water management tools for ensuring sustainability of ground water resources and should therefore be resorted to wherever possible/feasible. It is essential to ensure the quality of recharge to prevent possible contamination/pollution of aquifer. The appropriate Government shall demarcate groundwater recharge zones by identifying critical natural recharge areas of an aquifer and those areas that require special attention with regard to the recharge of groundwater and including areas that are affected by contaminants and saline water ingress. The groundwater recharge zones shall be accorded the highest priority in terms of groundwater protection and regulation and the appropriate government shall take all possible measures to conserve and protect such groundwater recharge zones.

#### 5.7.9 Demand Management, Water Pricing and Participatory Management

336. The main considerations are:

- i. An Independent statutory Water Regulatory Authority shall be established by every State for ensuring equitable access to water for all and its fair pricing, for drinking and other uses such as sanitation, agricultural and industrial. The decisions of the Water Regulatory Authority shall be subject to judicial review.
- ii. The principle of differential pricing for water for drinking and sanitation; and for ensuring food security and supporting livelihood for the poor may be adopted. The appropriate Government might provide minimum quantity of water for drinking and sanitation free of cost or at a subsidized price to eligible households, being part of pre-emptive need. The available water, after meeting the pre-emptive needs, shall increasingly be subjected to allocation and pricing on economic principles so that water is not wasted in unnecessary uses and could be utilized more gainfully and water infrastructure projects are made financially viable.
- iii. Water charges should be determined on volumetric basis in order to meet equity, efficiency and economic principles. Such charges should be reviewed periodically. Hence, low cost measurement structures should be installed in the canals.
- iv. Free of cost water supply to forest dwelling STs and other Traditional Forest Dwellers for drinking water and farming needs may be considered as they help in maintaining forested watersheds.
- v. Water Users Associations (WUAs) should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction. WUAs should be given the freedom to fix rates subject to floor rates determined by WRAs. Women should be encouraged for involvement in WUA and also in decision making activities in management of canals and command areas. The irrigation system should be planned, developed and managed in consultation with prospective water user groups. Government should progressively transfer management of irrigation command areas to WUAs and support and build their capacity for management.
- vi. Urban and rural water supply as well as supply for all the sectors shall be 100% metered and priced on volumetric basis. Provided that supply of minimum water to Below Poverty Line populations may be subsidised by the appropriate government.

- vii. Water accounts and water audit reports indicating leakages and pilferages, shall be published to sensitize communities for reduction of non-revenue water uses taking into due consideration the associated social issues.
- viii. Tariff rates have to be so revised as to cover not only the O&M costs but also part of the capital cost, debt service plus some reserve fund.
- ix. Tariff rates have to be prescribed such that the industry feels compelled to look into technological interventions leading to reduced use per unit production. For effecting maximum conservation, production processes have to be improved, to have lesser generation of effluent water.
- x. Pricing of water for industry shall include efficiency costs and capital charges.
- xi. Measures should be taken to increase revenue from water rates. For such increases to be accepted, utility and efficiency of the system should be increased through savings of working expenses through modernization, better water management, organisational reforms, improved infrastructure and reorientation in O&M costs by curtailing overstaffing, providing better communications and establishing participatory management.
- xii. The subsidy on water rates to the disadvantaged and poorer sections of the society should be well targeted and transparent. The water rates should cover the entire annual O&M cost plus a part (say 1% )of the gross value of the produce/ ha in respect of cereal crops and higher percentage in case of cash crops. The O&M component should be fully utilized for the operation and maintenance of the respective portions of the system. The second part should be used to modernize the system with supplementation from budget allocations. Each State will have to decide the natural proportion of the two components based on its figures of O&M and the productivity of the crops. The financial procedures should be modified to make this possible, so that the farmers are encouraged to pay the enhanced rates. The rate structure should differentiate between the seasons and also the crops in such a way that production or benefits are optimized per unit of water or at least indicate the intention. Thus the rates should be so rationalized that the water intensive crops are charged proportionately more as compared to less water consuming crops.
- xiii. On the basis of previous hydrological records, the existing surface irrigation projects should be classified into those with performance reliability of (a) 75% or above and (b) less than 75%. Considering a minimum reliability of 50%, the water rates for the latter should be two-thirds of the full rates fixed for the former. The objective should be to achieve volumetric measurement ultimately, though gradually, and this should be kept in mind at every stage. The change should encourage user group formation and give adequate incentive to group consumers, who can be supplied water on volumetric basis, over individual consumers who have to be charged on crop area basis.
- xiv. In the case of supplies for industrial purposes, the principle of ‘user pays, polluter pays’ has to be applied and water charges fixed accordingly, adopting a premium for security, in water scarce regions. In the case of domestic supply, a certain fixed quantity per connection may be fixed, in addition to the public taps, and charges increased progressively for larger use. The principle of seasonal water rates could also be tried.

#### 5.7.10 Environmental Aspects

337. The main considerations are:

- i. The environmental protection plan, including cumulative environment impact assessment, for an area shall form part of the Master river basin management Plan

- ii. Environmental needs of Himalayan regions, aquatic eco-system, wet lands and embanked flood plains need to be recognized and taken into consideration while planning
- iii. The project authority should weigh all alternatives before going in for a project so as to cause the least social and environmental disturbance.
- iv. A catchment treatment program for arresting the degradation of the catchment areas and restoring ecological balance needs to be planned and monitored as part of a project.
- v. Integrated watershed projects help in water and soil conservation and thus enable restoration of degraded areas. Therefore, integrated watershed development activities with groundwater perspectives need to be taken in a comprehensive manner to increase soil moisture, reduce sediment yield and increase overall land and water productivity. To the extent possible, existing programs like MGNREGA may be used by farmers to harvest rain water using farm ponds and other soil and water conservation measures.
- vi. To mitigate the adverse impacts of submergence of forest area, a compensatory afforestation plan, bio-diversity conservation program and wildlife conservation plan to rehabilitate / protect the wildlife species should be fully implemented as approved.
- vii. Adequate Fishery Management Plans with provision of hatchery and fish ladder etc, for sustainable u/s aquaculture shall be provided. To sustain the riverine ecology in d/s of project, release of adequate minimum flow shall be ensured in the river d/s of project.
- viii. Green belt development around the periphery of reservoir to check air and noise pollution is needed, to protect the slip zones / landslides around the rim of reservoir, biological and engineering treatment shall be ensured.
- ix. Monitoring and Evaluation of environmental safeguards during the construction phase and in post operation phase as stipulated in EIA clearance, is essential.

#### 5.7.11 Rehabilitation and Resettlement

338. The main considerations are:

- i. Much of the criticism against major developmental projects including water projects emanate from poor R&R, and therefore, R&R of PAPs should receive due attention and should be done in accordance with the provision of the relevant policies/Acts in force .
- ii. The R&R plan should be prepared along with the project but implemented well ahead of the project completion. There should be perfect timing so that all PAPs are settled well before the reservoir is filled. R&R should be taken as the obligation towards the affected persons, who have to suffer on account of the project and should be dealt with human compassion and sensitivity.
- iii. The R&R plan should receive sufficient funds and should be implemented by an independent authority. It should be vested with powers to deal with the affairs of the State / Basin, to the extent possible. Implementation of R&R should also be monitored and evaluated by an independent agency.
- iv. Special care should be taken that the minimum extent of land required alone is proposed for acquisition.
- v. The project advisory steering committee must be broad based to include representatives of the PAPs, NGOs and representatives drawn from the concerned departments / agencies.

- vi. Apart from periodic assessment of the R&R plan, there should be an assessment made 5-7 years after its full implementation, to see how the PAPs have done for themselves. If further support/ interventions are required, they must be provided.
- vii. A complete survey of the affected zone and people, their occupations etc. should be taken in this respect, wherever tribals are involved.
- viii. Compensation packages should be well laid down to take care of all categories of displaced persons. They would include land for land, homestead for all including the landless, cash compensation, training for vocations, employment and so on.
- ix. As far as possible, cash compensation is not to be considered for tribals as they are tied to land in their way of life and are not careful in handling money.
- x. Tribals must be given special attention. They should as far as possible be settled in habitats, closer to the ones left behind by them and without breaking their group identity.
- xi. The resettled sites should be well developed with all infrastructure so as to provide the resettled a better way of life.
- xii. Support to the landless, unemployed should be extended, through appropriate means, to enable them to rehabilitate themselves.
- xiii. There should be active involvement of the displaced in the R&R activities and flexibility to the extent required should be built into the plan.
- xiv. NGOs should be involved to the maximum extent possible, in the formulation, implementation and follow up of the R&R plan. They are based locally and will be able to build up the confidence of the resettled PAPs.
- xv. Infrastructure, training material etc. should be improved and updated to increase the efficiency of the institutions and persons involved in the sector so as to effectively deal with R&R and environmental issues.

#### 5.7.12 Water Quality Aspects

339. The main considerations are:

- i. Subject to the provisions of the Environment (Protection) Act 1986 and Water (Control and Prevention of Pollution) Act 1974, the approach to the prevention and control of pollution and contamination of water sources shall include: (i) minimising the generation of waste in all water uses; (ii) reducing non-point source of pollution; (iii) recovering, to the extent possible, water for some uses from waste; and (iv) ensuring that nothing that does not meet certain stringent quality standards, to be prescribed, is allowed to enter water sources.
- ii. There is need to establish and operate cost - effective water quality monitoring systems on seasonal / monthly scales as well as long-term scale, in varying scenarios in the basin at different stages. Adverse effects of agricultural activities on water quality are to be prevented. It is essential to establish biological, physical, chemical water quality criteria for users. Action is to be taken to minimize soil runoff and sedimentation. Proper disposal of sewage is to be ensured. Communities are to be educated about the pollution-related impacts of fertilizers and chemicals on water quality.
- iii. Application of 'polluter pays' principle is needed to prevent water pollution. Treatment facilities for domestic sewage and industrial effluents are to be improved and standards for discharge of effluents properly implemented and monitored.

- iv. Mandatory EIA of all major water resources development projects, use of risk assessment and risk management in reaching decisions, identification and application of best environmental practices are needed to avoid pollution.
- v. To restore and maintain water quality and ensure environmental sustainability, action is needed on a wide front under water resources protection and conservation, water use efficiency, water quality management, drainage and control of water logging and salinity, prevention and control of water pollution, development and application of clean technology, and ground water protection.
- vi. The appropriate Government and local Authority shall take all possible measures to protect and improve the quality of groundwater, includes measures for prevention of pollution and for remediation from groundwater contamination. It shall also ensure planning and implementation of necessary safeguards to protect the quality of groundwater while giving licenses for mining and industrial activities.

#### 5.7.13 Inter-basin Transfers

340. The main considerations are:

- i. The approach to inter-basin transfer is that optimal utilization of land and water should first be aimed at, in basins with possible surpluses. After meeting such essential requirements, if there is surplus water available in the basin, its transfer to other basins may be considered.
- ii. Water balance study of the source basin should be undertaken including existing and planning water uses, downstream and interstate requirement, environment needs to decide availability of supply water. Likely impact of climate change may also be considered.
- iii. Inter-basin transfer of water is a large and complex program of water management. Therefore, studies have to be done with the help of computer simulation models and systems analysis capable of handling large data. Computer simulation models are urgently required even for intelligent and coordinated operation of a number of storages already built or under construction in these basins. Social and environmental impact studies as well as studies on economic viability have also to be undertaken on an elaborate scale.

#### 5.7.14 Interstate Issues

341. Potential conflicting interests in interstate river basins can be overcome through mutual trust and understanding between the States, appropriate legal and institutional frameworks, joint approaches to planning and management, and sharing of the ecological and socio-economic benefits, and related costs. More options, including multi-purpose uses and joint projects, appear when issues and relations between riparian States and related sectors are treated together. Top-down basin-wise approaches based on constructive ambiguity principles are often essential to foster trust and trigger action for cooperation due to the political nature of allocation of interstate water resources.

#### 5.7.15 International Dimensions

342. The main considerations are:

- i. The optimized and integrated development of international rivers calls for cooperation amongst the co-basin countries. In an increasingly global economy, to attain the goals of poverty alleviation and sustainable economic growth, the regional integration and cooperation are necessary.

- ii. Since water does not recognize borders, regional cooperation at the scale of the whole basin is essential for water related developments as development in one country may have consequences in another country.
- iii. Cross border water monitoring and establishment of common regional standards as in many other matters, would be very useful. The threat of global warming and climate change has engendered new concerns. The point to study and appropriate action in South Asia is the extent to which emissions trading can be used to generate funds for clean Himalayan hydro power and in negotiating the fine print so that the terms are rightly defined and expressed.
- iv. Flood moderation and forecasting is a matter of common concern and there is need for improving hydrological and silt data transmission in real time. Likewise, flood embankments need to be tied together across national boundaries. There has to be agreement on construction of anti-erosion and flood protection works along common or successive rivers so that one country's solution does not cause problems to the other.
- v. There is a need for a joint water resources development program at basin scale, owned and managed by the riparian countries themselves, in close cooperation with the technical institutions, investment institutions and civil society.
- vi. Transparency, public awareness and stakeholder participation are the pathways to future water resources development. This will be more so in respect of trans-boundary projects. Capacity building for regional water resources development is also necessary. The emphasis should be on maximizing local manpower, material and equipment, then going to the regional level and only thereafter going international in order to save heavy foreign exchange outgoes and to build national and regional self-reliance.
- vii. In the matter of capacity building, the role of universities, research institutions and NGOs has to be adequately recognized and promoted. It is essential that the scientific as well as the techno-socio-economic aspects of various issues are not allowed to be obscured by parochial and emotional considerations. Towards this the efforts should be mounted and sustained by nurturing and strengthening suitable institutions which can also play a role in the creation of public awareness about issues relating to international water resources.

#### 5.7.16 Water Resources Development and Management at Local Level

343. The main considerations are:

- i. In a basin, there is a place for the whole range of structures - large to small, the latter has a particularly important role in many regions of the country.
- ii. Renovation and modernization of tanks and other local water resources are to be considered as priority task. The program needs to be planned and implemented on a watershed basis, taking into account the comparative techno-economic feasibility of renovating existing tanks vis-à-vis construction of supplementary tanks, upstream and downstream.
- iii. There is need for optimum use of local sources of water even in canal-irrigated areas, in the interests of efficiency of water use, extension of irrigated land, prevention of water-logging and increased productivity.
- iv. Due importance should be given to local water planning, with the ultimate aim of making each rural area manage its own water needs as far as possible through water harvests, conservation measures and watershed development.
- v. At every stage, from the very beginning, people concerned must be involved in working out the project plan. A data base needs to be established and constantly updated at the

district level. Operation and maintenance of local water harvesting schemes may be transferred to local water users.

- vi. State Governments should establish technical bodies at the local level for constant interactive relationships between the programs and the people on technical matters and for use of low-cost local materials.
- vii. The Government of India should bring together all the area programs of different Ministries as well as the rural employment and development programs into one 'Integrated Rural Area Program' (IRAP). For each eco-system-arid, semi-arid, dry-sub-humid, hill, wastelands, wetlands, heavy rainfall regions, irrigated plains - different, location- specific programs may be drawn up locally under this overall program. All the existing programs may be merged in this and need not continue on parallel lines. New Schemes should not be added on an ad-hoc basis.

#### 5.7.17 Information and Knowledge Management

344. The main considerations are:

- i. It is necessary to build systematically a data and information system, scientific in approach and comprehensive in coverage, simultaneously with a system of data exchange and information dissemination in order to address all concerns in the water sector effectively through research and development.
- ii. Monitoring of surface water and groundwater quantity and quality should be undertaken to support water resources management. Monitoring systems and databases, data standards and protocols should follow national standards.
- iii. Data should be shared between departments and levels of government freely other than for the costs of data transfer and made accessible to the public consistent with national security requirements.
- iv. Decision support system including integrated modeling should be used to develop river basin and watershed management plans and to support the development of government policy.

#### 5.7.18 Research and Developmental Needs

345. The main considerations are:

- i. Considerable work has been done regarding surface water availability, but as the studies themselves indicate, further refinement is warranted. Surface water availability studies need to be refined through the modelling of the hydrological cycle using modern technology like Remote Sensing and GIS. One issue that may be mentioned is further analysis of contribution from snowmelt and glaciers, which is particularly important in the Himalayan rivers. Another important component to be studied is assessment of the return flows from different uses.
- ii. Desalination of saline and sea water is a relatively high cost alternative, normally employed as the last resort. However, in arid areas near the sea coast, it may be competitive with tanker supply and may prove viable. Continuous improvements in membrane technology are bringing down the costs and research needs to be stepped up in this area.
- iii. Estimation of water demand and its implications on water quantity and quality are extremely important. Related to it is the management of water demand, through technology, policy and specifications. For planning purposes, more refinement in the

assessment of water demand is needed particularly through the use of standardized water footprints.

- iv. Research and Development should be closely linked with the needs of the water resources managers and users. Research is needed to provide guidance to the farmers in particular, to obtain maximum production per unit of water for different crops suited to their climatic and soil conditions. Crop planning itself has an important bearing on water demand and of course on farmer's income.
- v. For domestic water supply, research needs to be directed towards supply of safe water at minimum cost. Evaluation of latest technologies for sedimentation, treatment and purification is needed. For sanitation, the evolving techniques using smaller quantity of water need to be evaluated and improved. For sewage treatment, research effort should be directed towards defining the design parameters for low cost energy intensive techniques, like oxidation and duckweed ponds. Recycling of treated wastes for industrial use and irrigation has to be promoted subject to requirements of safety.
- vi. Research is needed on the actual observed impact of existing high dams and other irrigation systems on environment with respect to river regime, ground water, flora and fauna, human health, quality of life etc.
- vii. Research is also needed to assess the impact of large scale interbasin transfers on donor and recipient basins with respect eco-system, sociology and economics.
- viii. The subject of climate change and its impact on water has been mentioned under issues to be taken into account while determining the development policy, but in view of the uncertainty of the subject, considerable research is required. This also raises the issue as to how uncertainty has to be handled in decision making. The subject needs considerable research.
- ix. Removal of silt from the reservoirs has been engaging attention since long. A cost effective method of removal of silt has yet to be devised. Desilting of reservoir is project specific. However research efforts are required for development of economic technologies for this purpose.
- x. More research effort needs to be directed towards environmental, legal, socio-economic aspects of irrigation and water resources development and management in general. The impact on income, employment etc. needs to be evaluated.
- xi. There are several fields where further research is needed for technological innovations such as in environmental flows, sedimentation studies, river morphology, forest hydrology, designs and model studies for specific structures, construction technologies, new materials etc.
- xii. The methodology for determination of nationally standardized water foot prints for every activity/product should be developed, tried and promoted according to the results.
- xiii. If the results of the research work are not properly documented, they do not become available to other potential users, who may be facing similar problems. It is extremely important that all research results are properly documented and published. The completion reports of important projects would record problems faced and solved and will be of high practical utility.
- xiv. There is need to update technology, design practices, planning & management practices, preparation of annual water balances and accounts for the project sites and basins. Benchmarking and performance evaluation of the projects should be given due importance for increasing the performance of existing and future projects.

- xv. Effective networking and coordination of research work done in different institutions is essential to maximize their benefit and avoid duplication of effort. Intercommunication between research workers active in the same field and in different disciplines enhances progress of the work and evolution of new policies and systems.
- xvi. Most of the big States have got institutions for research such as Irrigation Research institutes and WALMIs. These need to be made autonomous organisations in order to ensure the continuity of the persons and to give them flexibility in their functions.
- xvii. A regular personnel training policy needs to be evolved by each government and organisation. This policy needs to provide for adequate training, with emphasis on acquisition of knowledge in the early career, on acquisition of skills in the middle period and on managerial aspects in the later period.
- xviii. There is a need for much larger horizontal mobility, within a specialization, amongst cadres and specialists. Similarly, exchange between academic institutes and line department personnel would be beneficial. Water professionals, at senior levels, could be given a choice to either branch into senior management and policy making responsibilities or continue in their specialized fields striving for professional excellence and towards becoming a role model to the younger generation. Such a move could go a long way in changing the prevailing attitudes about coordination, management, administration and policy making to a healthy and superior level.