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The World Bank

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Report No: PAD1429

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED LOAN

IN THE AMOUNT OF US$175 MILLION

TO THE

REPUBLIC OF INDIA

FOR THE

NATIONAL HYDROLOGY PROJECT

{February 3, 2017}

Water Global Practice
South Asia Region

CURRENCY EQUIVALENTS

(Exchange Rate Effective as of January 12, 2017)

Currency Unit = INR

INR 68.36 = US$1

FISCAL YEAR

April 1 – March 31

ABBREVIATIONS AND ACRONYMS

AWP	Annual Work Plan
BBMB	Bhakra-Beas Management Board
BCA	Benefit-cost Analysis
CAG	Comptroller and Auditor General
CBWRM	Community-Based Water Resources Management
CGWB	Central Groundwater Board
CPMU	Central Project Management Unit
CPCB	Central Pollution Control Board
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
DEM	Digital Elevation Model
DGS&D	Directorate General of Supplies and Disposals
DSS	Decision Support Systems
EA	Environmental Assessment
e-SWIS	Online Surface Water Information System
FM	Financial Management
FYP	Five-year Plan
GDP	Gross Domestic Product
e-GEMS	Online Groundwater Estimation and Management System
GIS	Geographic Information System
GO	Government Order
GOI	Government of India
GPRS	General Packet Radio Service
GSM	Global System for Mobile
HIS	Hydrological Information System
HP-I	Hydrology Project Phase 1
HP-II	Hydrology Project Phase 2
IA	Implementing Agency
ICB	International Competitive Bidding
IMD	Indian Meteorological Department
IT	Information Technology
IUFR	Interim Unaudited Financial Report
IWRM	Integrated Water Resources Management
M&E	Monitoring and Evaluation
MCM	Million Cubic Meters
MIS	Management Information System
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding

MoWR, RD&GR	Ministry of Water Resources, River Development, and Ganga Rejuvenation
MTR	Midterm Review
NCB	National Competitive Bidding
NGMIP	National Groundwater Management Improvement Program
NHP	National Hydrology Project
NIH	National Institute of Hydrology
NPMU	National Project Management Unit
NPV	Net Present Value
NRSC	National Remote Sensing Center
NWIC	National Water Informatics Center
O&M	Operations and Maintenance
PAD	Project Appraisal Document
PAO	Pay and accounts Officer
PDO	Project Development Objective
PIP	Project Implementation Plan
PMKSY	Prime Minister's Irrigation Scheme (*Pradhan Mantri Krishi Sinchaiyee Yojana*)
PMU	Project Management Unit
RBO	River Basin Organization
RBPMU	River Basin Project Management Unit
RTDAS	Real Time Data Acquisition System
RTDSS	Real-Time Decision Support System
SBD	Standard Bidding Document
SCADA	Supervisory Control and Data Acquisition
SOI	Survey of India
SPMU	State Project Management Unit
STEP	Systematic Tracking of Exchanges in Procurement
TAMC	Technical Assistance and Management Consultancy
UT	Union Territory
WALMI	Water and Land Management Institute
WRIS	Water Resources Information System
WUA	Water Users Association

Regional Vice President:	Annette Dixon
Country Director:	Junaid Kamal Ahmad
Senior Global Practice Director:	Guang Zhe Chen
Practice Manager:	Meike van Ginneken
Task Team Leader:	Anju Gaur/C.R. Singh

INDIA
National Hydrology Project

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PAD DATA SHEET

India

National Hydrology Project (P152698)

PROJECT APPRAISAL DOCUMENT

SOUTH ASIA

0000009396

Report No.: PAD1429

Basic Information		
Project ID P152698	EA Category B - Partial Assessment	Team Leader(s) Anju Gaur/ Chabungbam Rajagopal Singh
Lending Instrument Investment Project Financing	Fragile and/or Capacity Constraints [ ] Financial Intermediaries [ ] Series of Projects [ ]	
Project Implementation Start Date 31-Mar-2017	Project Implementation End Date 31-Mar-2025	
Expected Effectiveness Date 30-Jun-2017	Expected Closing Date 31-Mar-2025	
Joint IFC No		

Practice Manager/Manager	Senior Global Practice Director	Country Director	Regional Vice President
Meike van Ginneken	Guang Zhe Chen	Junaid Kamal Ahmad	Annette Dixon

Borrower: Ministry of Finance Department of Economic Affairs					
Responsible Agency: Ministry of Water Resources, River Development & Ganga Rejuvenation					
Contact:	Dr. Amarjit Singh		Title:	Secretary, Ministry of Water Resources, River Development &	
Telephone No.:	23715919		Email:	secy.mowr@nic.in	

Project Financing Data(in USD Million)					
[X] Loan	[ ] IDA Grant	[ ] Guarantee			
[ ] Credit	[ ] Grant	[ ] Other			
Total Project Cost:	350.00		Total Bank Financing:	175.00	
Financing Gap:	0.00				

Financing Source	Amount
Borrower	175.00
International Bank for Reconstruction and Development	175.00
Total	350.00

Expected Disbursements (in USD Million)

Fiscal Year	2018	2019	2020	2021	2022	2023	2024	2025	0000	0000
Annual	12.00	15.00	25.00	30.00	25.00	30.00	25.00	13.00	0.00	0.00
Cumulative	12.00	27.00	52.00	82.00	107.00	137.00	162.00	175.00	0.00	0.00

Institutional Data

Practice Area (Lead)

Water

Contributing Practice Areas

Agriculture, Climate Change, Governance

Proposed Development Objective(s)

The proposed project development objective (PDO) is to improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of targeted water resources management institutions in India.

Components

Component Name	Cost (USD Millions)
Water Resources Monitoring System	150.00
Water Resources Information Systems	50.00
Water Resources Operations and Planning System	66.00
Institutional Capacity Enhancement	84.00

Systematic Operations Risk- Rating Tool (SORT)

Risk Category	Rating
1. Political and Governance	Low
2. Macroeconomic	Low
3. Sector Strategies and Policies	Substantial
4. Technical Design of Project or Program	Substantial
5. Institutional Capacity for Implementation and Sustainability	Substantial
6. Fiduciary	Substantial
7. Environment and Social	Low

8. Stakeholders	Low
9. Other	High
OVERALL	Substantial

Compliance

Policy

Does the project depart from the CAS in content or in other significant respects?	Yes [ ] No [X]
Does the project require any waivers of Bank policies?	Yes [ ] No [X]
Have these been approved by Bank management?	Yes [X] No [ ]
Is approval for any policy waiver sought from the Board?	Yes [ ] No [X]

Explanation:

The approval for an exception to the riparian notification requirement of paragraph 7(b) of OP/BP 7.50: Projects on International Waterways has been obtained from the RVP. The details are available in ISDS sheet.

Does the project meet the Regional criteria for readiness for implementation?	Yes [X] No [ ]

Safeguard Policies Triggered by the Project	Yes	No
Environmental Assessment OP/BP 4.01	**X**	
Natural Habitats OP/BP 4.04		**X**
Forests OP/BP 4.36		**X**
Pest Management OP 4.09		**X**
Physical Cultural Resources OP/BP 4.11		**X**
Indigenous Peoples OP/BP 4.10		**X**
Involuntary Resettlement OP/BP 4.12		**X**
Safety of Dams OP/BP 4.37		**X**
Projects on International Waterways OP/BP 7.50	**X**	
Projects in Disputed Areas OP/BP 7.60		**X**

Legal Covenants

Name	Recurrent	Due Date	Frequency
Project Implementation Unit	**X**		CONTINUOUS

Description of Covenant

(a) The Borrower shall maintain, throughout the period of implementation of the Project, with functions, terms of reference and composition satisfactory to the Bank, the following bodies: (a) the National Steering Committee, (b) the National Project Monitoring Unit, and (c) Central Project Management Units in each of the Central Agencies.

(b) The Borrower shall cause each of the Participating States to establish, and thereafter maintain, through the period of implementation of the Project, with functions, terms of reference and composition satisfactory to the Bank: (a) the State Project Steering Committee; and (b) the Project Management Units.

(c) The Borrower shall cause each of the Regional Based Organizations to establish, and thereafter maintain, through the period of implementation of the Project, with functions, terms of reference and composition satisfactory to the Bank, the Project Management Units.

Name	Recurrent	Due Date	Frequency
Project Implementation Plan	X		CONTINUOUS

Description of Covenant

The Borrower shall, and shall cause each of the Project Implementing Entities to, adopt and thereafter maintain, throughout the period of implementation of the Project, the Project Implementation Plan in inform and substance satisfactory to the Bank

Name	Recurrent	Due Date	Frequency
Annual Work Program	X		Yearly

Description of Covenant

The Borrower shall (a) by no later than December 31 in each year and with the participation of each of the Project Implementing Entities furnish to the Bank for its review and comments a proposed annual work plan and budget for the following fiscal year, giving details of the proposed work Project activities, cost estimates and budget proposals for the Project for the forthcoming fiscal year; and (b) proceed thereafter to implement such annual work plan and budget, with the participation of the Project Implementing Entities, taking into account such comments as may have been made thereon by the Bank.

Name	Recurrent	Due Date	Frequency
Technical Assistance and Management Consultant		31-Aug-2017	

Description of Covenant

The Borrower shall engage and maintain a Technical and Management Support Consultant to assist in the implementation of the Project.

Name	Recurrent	Due Date	Frequency
Annual Review and Project Outlay	X		Yearly

Description of Covenant

The Borrower shall undertake with the participation of each of the Project Implementing Entities, not later than October 31 of each year, an annual review of the Project. The Borrower shall not later than June 30, 2019 and June 30, 2022, carry out two mid-term reviews of the Project, and shall incorporate the findings of such review in the work programs of subsequent years adjusting the Project outlay for the Project Implementing Entities based on their performance in agreement with the Bank.

Name	Recurrent	Due Date	Frequency
National Water Information Center		31-March-2018	

Description of Covenant

Name	Recurrent	Due Date	Frequency

The Borrower shall establish, and thereafter maintain throughout the period of implementation of the Project, an independent national water information center to operate and maintain the web-based India-WRIS referred to in Part B.1 of the Project under terms of reference satisfactory to the Bank.

Name	Recurrent	Due Date	Frequency
Budgetary provisions and releases by MoWR, RD&GR	X		Yearly

Description of Covenant

The Borrower shall make budgetary provisions sufficient to implement the work program referred starting fiscal year 2016–17 and will ensure the release of funds to all the designated implementing agencies as per agreed milestones and for each subsequent fiscal year thereafter until project completion.

Name	Recurrent	Due Date	Frequency
Computerized Financial Management System		31-March-2018	

Description of Covenant

The Borrower shall establish and thereafter maintain with the assistance of the Project Implementing Entities through the period of implementation of the Project, a computerized financial management system.

Name	Recurrent	Due Date	Frequency
Financial Audit	**X**		Yearly

Description of Covenant

The Borrower shall, and shall cause each Project implementing Entity to, have the Project Financial Statements audited in accordance with the provisions of Section 5.09 (b) of the General Conditions. Each audit of the Project Financial Statements shall cover the period of one fiscal year of the Borrower and each Project Implementing Entity, commencing with the fiscal year in which the first withdrawal was made. The audited Project Financial Statements for each such period shall be furnished to the Bank not later than nine (9) months after the end of such period.

Team Composition

Bank Staff

Name	Role	Title	Unit
Anju Gaur	Team Leader (ADM Responsible)	Sr Water Resources Spec.	GWA06
Chabungbam Rajagopal Singh	Team Leader	Water Resources Mgmt. Spec.	GWA06
Arun Kumar Kolsur	Procurement Specialist (ADM Responsible)	Senior Procurement Specialist	GGO06

Krishnamurthy Sankaranarayanan	Financial Management Specialist	Sr Financial Management Specialist	GGO24
Halla Maher Qaddumi	Team Member	Senior Water Economist	GWA06
Jai Mansukhani	Team Member	Senior Program Assistant	SACIN
Minerva S. Espinosa-Apurada	Team Member	Program Assistant	GWA09
Nagaraja Rao Harshadeep	Team Member	Lead Environment Specialist	GENDR
Pyush Dogra	Environmental Specialist	Senior Environmental Specialist	GEN06
Samuel Thangaraj	Safeguards Specialist	Consultant	GSU06
Satya Priya LNU	Team Member	Sr Water Resources Mgmt. Spec.	GWA06
Shankar Narayanan	Team Member	Senior Social Development Specialist	GSU06
Suryanarayana Satish	Safeguards Specialist	Senior Social Development Specialist	GSU06
Tapas Paul	Safeguards Specialist	Lead Environmental Specialist	GEN06
Victor Manuel Ordonez Conde	Team Member	Senior Finance Officer	WFALA
William Young	Team Member	Lead Water Resource Management Specialist	GWA09

Extended Team

Name	Title	Office Phone	Location
Anish Kumar	Consultant	9780444276	
Carter Borden	Consultant	12089727906	
Christopher Ward	Consultant	447717885997	
Hitesh Kumar Thakur	Consultant	8585981594	
Johan Grijsen	Consultant	15126180023	
Pooja Khosla	Consultant	9971217215	
Steve Lipscomb	Consultant	011-49247000	
Steven Parson	Consultant	9313665222	

Locations

Country	First Administrative Division	Location	Planned	Actual	Comments
India	West Bengal	West Bengal	**X**		

India	Uttar Pradesh	Uttar Pradesh	**X**		
India	Tripura	Tripura	**X**		
India	Telangana	Telangana	**X**		
India	Tamil Nadu	State of Tamil Nadu	**X**		
India	Sikkim	Sikkim	**X**		
India	Rajasthan	State of Rajasthan	**X**		
India	Punjab	State of Punjab	**X**		
India	Pondicherry	Union Territory of Puducherry	**X**		
India	Odisha	State of Odisha	**X**		
India	Nagaland	State of Nagaland	**X**		
India	Mizoram	Mizoram	**X**		
India	Meghalaya	Meghalaya	**X**		
India	Manipur	Manipur	**X**		
India	Maharashtra	State of Maharashtra	**X**		
India	Madhya Pradesh	Madhya Pradesh	**X**		
India	Kerala	State of Kerala	**X**		
India	Karnataka	State of Karnataka	**X**		
India	Himachal Pradesh	State of Himachal Pradesh	**X**		
India	Haryana	State of Haryana	**X**		
India	Gujarat	State of Gujarat	**X**		
India	Goa	Goa	**X**		
India	NCT	National Capital Territory of Delhi	**X**		
India	Bihar	State of Bihar	**X**		
India	Assam	Assam	**X**		
India	Andhra Pradesh	State of Andhra Pradesh	**X**		
India	Chhattisgarh	State of Chhattisgarh	**X**		
India	Jharkhand	State of Jharkhand	**X**		
India	Uttarakhand	State of Uttarakhand	**X**		

I. STRATEGIC CONTEXT

A. Country Context

1. India is the second most populous country in the world, with a population of 1.3 billion (2015) growing at 1.2 percent per year. The gross domestic product (GDP) is approximately US$2 trillion. Per capita income in 2015 was US$1,590. India is one of the world's fastest growing economies (6–9 percent per year during last decade) and poverty rates have declined by an average of 2.5 percentage points per year. Significant changes are occurring in sectoral contributions to GDP: agriculture's contribution to GDP fell from approximately 40 percent in the 1970s to 17 percent in 2014, while the contribution of services and industry grew to 53 percent and 30 percent, respectively.

2. Large extent of the country is subjected to climate extremes including flood and droughts. The rainfall is highly seasonal with 50% of precipitation falling in just 15 days and over 90% of river flows in just four months. It is estimated that around 68 percent area is drought prone[1] and 12 percent is affected by floods. More than 3 million people are affected annually by floods, at an average annual cost to the economy of US$1 billion[2]. Climate change will further exacerbate this problem and is estimated to contribute losses of up to 3% of projected GDP. As a result of population and economic growth, water demand is projected to double by 2050. Demand will increase in all sectors, but is especially significant in the industrial and domestic sectors which have been pillars of economic growth during last decade. Overall, India is ranked the second most vulnerable country in the world. Institutions and mechanisms for addressing climate extremes, especially in agriculture and water-intensive sectors, are either weak or nonexistent.

3. Notwithstanding agriculture's declining share of GDP, the agriculture sector employs 50 percent of the labor force and is critical to the socioeconomic fabric of the country. While India has made remarkable progress and economic growth is projected to remain strong, the country continues to face daunting development challenges. Approximately 20% of the Indian population still live on less than US$1.90 per day. Two-thirds of the population is rural, with 26 percent poor and largely dependent on farming. Although India's ranking on the United Nation's Human Development Index has improved, India still is ranked 130th of 188 countries in 2015.

B. Sectoral and Institutional Context

India's Water Resources Challenges

4. On a national level, India can be considered to have an abundance of water resources. India's total renewable water resources are estimated at 1,869 billion m^3, including about 1,123 billion m^3 of annual utilizable water resources. More than 60 percent of India's water is in transboundary basins. There are 12 major river basins and 46 medium river basins in the country, which are interstate across 29 states and 7 union territories (UTs). In northern India, the Indus, Ganga, and Brahmaputra are major transboundary river basins and also house the majority of

[1] Government of India, the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD&GR,), http://wrmin.nic.in/forms/list.aspx?lid=312.
[2] Government of India, Planning Commission, Twelfth Fiver 12th five-year plan, (FYP), 2013.

India's population. Out of India's total annual surface water resources, the Ganga and Brahmaputra basins account for 60 percent of streamflow and 70 percent of the population of the country.

5. However, overall averages mask significant spatial and temporal variations. Growing populations and rapid economic development have translated into demand for water outstripping supply in many areas and into growing inter-sectoral competition for available water. Water storage that could increase supply is relatively limited, amounting to 210 m^3 per capita as compared to 3,223 m^3 in Australia and 25,337 m^3 in Canada. Groundwater is under severe pressure, with more than half of the resource developed for use and over extraction prevalent in many intensively farmed areas. Demand for water is projected to nearly double by 2050 (to reach 1,069 billion m^3 as compared to the current 659 billion m^3). Demand will continue to rise in all sectors, particularly in the industrial and domestic sectors, placing pressure on agriculture, which currently accounts for 90 percent of water use. National programs such as the Prime Minister's Irrigation Scheme (*Pradhan Mantri Krishi Sinchaiyee Yojana*, PMKSY), which aims to ensure irrigation water supply to every field in India, already face water constraints due to overexploitation of groundwater, limited water availability in surface storage, and growing demand for reallocation of agricultural water to other priority sectors.

6. The quality of surface water and groundwater is a rising concern, decreasing effective water availability further. According to the Central Groundwater Board (CGWB), groundwater in 276 of India's 660 districts has high levels of fluoride; in 387 districts, it has nitrates exceeding safe levels; and in 86 districts, it has arsenic. According to the Central Pollution Control Board (CPCB), about 650 major towns and cities in India are on the banks of rivers contaminated with pesticides from farms and effluents from industries.

7. Many river basins in (particularly south) India are regulated by reservoirs to serve as a cushion for flood and drought. In the northern river basins, Ganga and Brahmaputra, the reservoirs and barrages are not sufficient to regulate effectively while alert and response systems are also not adequate to prepare for the floods. Even in regulated basins, the flood management is hampered by the lack of advanced hydrological forecasts combined with weather forecasts and the absence of integrated reservoir operations and timely warning for preparedness. Although states are responsible for the operation of reservoirs, they seek the help of the Central Water Commission (CWC) for streamflow forecasting. Reservoir operations are still based on original operating rules and are not geared to the flexible release of water to better manage flood risk and optimize storage. Preparedness for drought is weakened by the lack of information on water availability that integrates both meteorological forecasts and assessments of water availability. The knowledge base and drought management capability are not adequate to provide early warnings on drought or to plan for appropriate responses. In the short term, this leads to poor drought alert capability. In the longer term, it translates into inadequate planning and investment in the large-scale watershed management programs and strategic development of water resources for irrigation that could minimize the impacts of drought.

8. Climate change will further exacerbate India's water resources management challenges. Changing climatic conditions could affect not only water availability but also water quality and demand. In regions that are sensitive to water stress (arid and semiarid regions of India), any shortfall in water supply will increase competition for water use for a wide range of economic, social, and environmental applications.

9. The challenge of managing water resources in India is particularly complex given the country's institutional structure and the roles and responsibilities at various levels of government. Under the Indian Constitution, water management is a state subject, with interstate river basins managed by each state under the guidance of the central government. At the state level, state agencies are responsible for planning, development, and management of water resources and hence, monitoring of water resources and use. They prepare detailed project reports and implement development projects for flood management, irrigation and drainage, and water supply. The Government of India (GOI) is responsible for interstate river planning and management issues, data validation for states, and clearances of large irrigation/hydropower projects on technical and economic grounds, among others. The MoWR, RD&GR guides the states through legislation, policies, strategies, and operational guidelines. The central ministry is supported by its key technical bodies—the CWC and the CGWB. The CWC, CGWB, and CPCB (under the Ministry of Environment, Forests, and Climate Change) are responsible for water resources assessment through monitoring surface water and groundwater (quality and quantity) at the macro and interstate levels, as well as providing technical quality control of developments proposed by states, for example, analyzing impacts and so on.

10. Water resources challenges faced by India are thus considerable and need to be addressed by adopting an integrated approach that considers all water uses and all water sources (surface water, groundwater, and so on) on a hydrologic/river basin basis. This requires sound information and knowledge on the water resource base and water uses, coupled with appropriate tools for analysis and decision making. There is a need to improve hydrological forecasting, particularly in the upper reaches of rivers; provide flood alerts; and integrate streamflow predictions with weather forecasts to advance the lead time for flood management, including integrated reservoir operation. The GOI is cognizant of the need to forge an integrated approach to developing, managing, and regulating both surface water and groundwater resources jointly at the basin and aquifer scale and must strengthen its institutional capacity for integrated water resources management (IWRM).

Water Resources Monitoring

11. The national government and most state governments have recognized the importance of IWRM to ensure water security for economic growth and poverty reduction and the critical role of a strong knowledge base and decision support systems (DSS) and products as an input to this process. Indeed, over the last 20 years, the World Bank has supported the country's ambitious program to strengthen water resources data collection and management in different parts of the country—in the southern (peninsular) states, Himachal Pradesh, and Punjab—through the two phases of the hydrology project (HP-I in 1995–2003 and HP-II in 2006–2014).[3]

12. HP-I and HP-II can be credited with a number of achievements. They supported establishing a Hydrological Information System (HIS) to provide validated and timely hydrometeorological data integrated at the state level. The projects built hydrometeorological observation networks for surface water and groundwater (quantity and quality), established data

[3] HP-I Credit (P010485, US$94.95 million) and HP-II Loan (P084632, US$91.58 million). HP-II covered 13 states: Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Pondicherry, Punjab, and Tamil Nadu and 8 central agencies: the Bhakra-Beas Management Board (BBMB), CPCB, CWC, CGWB, Central Water and Power Research Station (CWPRS), Indian Meteorological Department (IMD), Project Coordination Secretariat (MoWR), and the National Institute of Hydrology (NIH).

processing and storage facilities, set up reliable data communications, and trained staff for operations and user support. The two projects also standardized database management and DSS for river basin operations, planning, and management; and helped modernize design, operation, and planning functions across water resources agencies. The HIS, together with modern software tools, supported improved structural designs for infrastructure, faster project report preparation, and selection of more cost-effective investment options.

13. HP-II was also instrumental in introducing real-time hydromet monitoring and DSS for reservoir operation and flood management. For the first time in India, real-time flood forecast systems integrated with weather forecast were introduced in two large river systems (Krishna and Satluj-Beas). As a result, the time available for early warnings on flood and preparation for flood management improved from hours to days, which led to saving hundreds of lives and avoided flood damages ranging from US$17 million to US$65 million in a year. Overall, HP-II enabled a paradigm shift in water information and water management in three principal ways: (a) from manual to automatic real-time monitoring and data transmission; (b) from simple operational water resources infrastructure management to advanced and effective operation management of key reservoirs; and (c) from data secrecy to greater transparency through online, real-time information systems. These changes contributed to a clear understanding at the state level of the importance of a river basin approach and of the key roles of water information and institutional capacity to apply information for planning and operations.

14. While HP-I and HP-II were under way, the MoWR, RD&GR established a web-enabled spatial Water Resources Information System (WRIS) of India (India-WRIS), making central information publically available. India-WRIS includes more than 90 spatial layers and real-time surface water data, covering predominantly southern India. However, there are several areas that need to be addressed to integrate India-WRIS with river basin information systems and make it effective for water resources management applications, including planning and operations. The primary ones are the following:

(a) **State HIS (including for HP-II states) are yet to be integrated into India-WRIS.** Although the databases in HP-II states are not yet integrated into India-WRIS, the data are in a standardized format and centralized database management software also exist, which will allow integration to take place relatively easily. However, there are significant challenges in the case of the northern region (the Ganga and Brahmaputra basins), where data are often sparse and records are largely manual and are neither validated nor in standardized format excepting for CWC data.

(b) **The national water resources assessment is not up-to-date, largely because data and information have not been systematically acquired, particularly on the demand side.** The last comprehensive water resources assessment exercise was completed in 1993 and it is being revised only now. During HP-II, it proved difficult to establish DSS for river basin planning and management because of poor access to water use information that is neither monitored nor standardized.

(c) **The data-sharing policy in the states needs to open up and be consistent with National Hydrometeorological Data Dissemination Policy (see in the following**

paragraphs). In the Ganga and Brahmaputra basins, data remain classified.[4] To integrate state data with the central system, data-sharing protocols and arrangements are required, including for sharing information on a real-time basis to support improved operations, planning, and management.

15. Despite the progress made under HP-I and HP-II, institutional capacity for IWRM, including flood and drought management, remains weak, particularly in the state water resources departments. During HP-II and through other projects, some states have been equipped with the tools for river basin planning and management, but there is generally little human resource capability for integrated management approaches. There is an acute shortage of hydrologists, water resources planners, water managers, and other skills.

16. Based on these recognized needs and experiences over the last twenty years in establishing the HIS in southern India and in Himachal Pradesh and Punjab, both national and state governments are now committed to building a comprehensive national WRIS that supports integrated river basin planning and management. The National Hydrology Project (NHP) responds to this demand by extending its reach to cover the entire country and ensuring that disparities between those states who participated in HP-I and HP-II are closed.

C. Higher Level Objectives to which the Project Contributes

17. The project is closely aligned with the GOI's water sector priorities set out in the 12th Five-year Plan (FYP)(2012–17), which calls for a paradigm shift toward integrated management of water resources based on improved systems for water data collection and information management and open access to water information. The FYP also calls for a renewed focus on nonstructural flood management and highlights the need for national aquifer mapping. An FYP working group recognized the value of accurate water resources information based on a national water information platform and, therefore, recommended an integrated national WRIS, which the MoWR, RD&GR has established, as noted. The GOI has made a commitment to continue its partnership with the World Bank, which was established during HP-I and HP-II, by investing in water resources information through the proposed project, adopting a programmatic approach, and financing the project on the national budget as a 'central sector scheme'.[5]

18. The key role of information and cooperation in its generation, sharing, and use is recognized by the comprehensive National Hydrometeorological Data Dissemination Policy (2013) which was introduced to facilitate data exchange among the national and state/UT agencies. The policy entitles web-registered users to freely download all unclassified hydrometeorological data. This policy is in line with the GOI's determination to improve efficiency and transparency

[4] The data on river water levels and discharge are classified in the transboundary river basins: (1) Indus; (2), Ganga, Brahmaputra, and Barak; and (3) minor rivers draining into Myanmar and Bangladesh. The reservoir water levels, live storage positions, yearly average data, historical important data (such as the highest flood level, yearly flood peak, and so on), water quality, and groundwater and meteorological data for all the regions are unclassified.

[5] In India's developmental plan, a 'central sector scheme' refers to a scheme introduced and fully funded by the union government. The GOI's Expenditure Finance Committee has recommended that the NHP be set up as a 'central sector scheme' and be fully funded as a program in the GOI budget.

of government through its new Digital India Initiative that seeks to electronically connect government departments and citizens for effective governance.

19. The World Bank's Country Partnership Strategy for India for the period FY2013–2017 (Report no 79176-IN) is aligned with the GOI's development vision for faster, sustainable, and more inclusive growth. It identifies India as the second most vulnerable country in the world to climate change, thus requiring enhanced disaster risk management. The proposed project will contribute directly to the objective of managing disaster risks by scaling up advanced flood management systems for early warning and improved reservoir operation, as well as enhancing river basin planning that would help identify both flood and drought risks and mitigation measures. These processes are particularly important in the light of climate projections that indicate an increasing frequency and intensity of extreme events under a changing climate.

20. The project also aims at converging with the information system and river basin approach being introduced under other ongoing projects while also supporting those projects with the standardized implementation arrangements. The NHP will seek to create synergies with ongoing or pipeline projects and programs, including the proposed National Groundwater Management Improvement Program (NGMIP) under the MoWR, RD&GR which is under preparation for World Bank support. The NHP aims to establish an enabling framework for surface water and groundwater management by strengthening information and DSS for water resources planning and management. The proposed NGMIP focuses on improving groundwater management by incentivizing a structured and informed process in participatory groundwater management that leads to changes in behaviors (actions and investment actions) on the ground. The NHP activities will provide important information to inform the planning and monitoring of site-specific solutions in the NGMIP. On the institutional and governance front, the NHP and the NGIMP will jointly work toward a stronger integration of surface and groundwater management at both the central and state levels and will support institutional capacity building to enable planning and management of water resources at various scales.

II. PROJECT DEVELOPMENT OBJECTIVES

A. PDO

21. The project development objective (PDO) is to improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of targeted water resources management institutions in India.

B. Project Beneficiaries

22. The project has two groups of direct beneficiaries: (a) central and state implementing agencies (IAs) responsible for surface water and/or groundwater planning and management, including river basin organizations (RBOs) and (b) users of the WRIS across various sectors and around the world. The ultimate beneficiaries will be the selected farm communities which benefited from pilot projects for water management; rural and urban water and power users; populations affected by floods and droughts, especially poor rural people, and farm families who may benefit from improved irrigation water supply and management; stakeholders across the energy, inland waterways, environment, and agriculture ministries; research and educational

institutions; students and researchers; and nongovernmental organizations, civil society organizations, and the private sector.

C. PDO Level Results Indicators

23. The PDO level results indicators are the following:

- Number of water resources monitoring stations operated by implementing agencies providing validated data online.
- Number of Information products produced under the project made available to the relevant stakeholders.
- Number of water resources institutions achieving benchmark performance levels.

III. PROJECT DESCRIPTION

A. Project Scope and Approach

24. The proposed project will support the expansion of the water resources monitoring system and institutional capacity for water resources management established in some states under HP-I and HP-II to cover the entire country, including the states of the Indus, Ganga, and Brahmaputra-Barak basins. HP-I and HP-II, which were focused in the peninsular states of India and in Himachal Pradesh and Punjab, established improved infrastructure for water resources data collection; developed standardized database management systems to validate, store, and process the data; and introduced DSS tools for water resources planning and real-time operation of water infrastructure in selected river basins.

25. The proposed NHP will further improve and expand the water resources monitoring system, strengthen water resources operation and planning systems, and enhance institutional capacity for water resources management. The project will improve access to information and will contribute to a culture change of open access to information. It will build up institutional capacity for evidence-based decision making in water resources planning and operational management at the basin scale across India using the latest technology and tools. The NHP will span both states that benefited from HP-I and HP-II and states that were not included in the earlier projects. For HP-I and HP-II states, support will focus on upgrading and completing networks including for monitoring water use. In the new states, support will be provided for adopting the standards and procedures for water resources monitoring and database management that were developed under the earlier projects. In all the states, the focus will be on integrating data in a comprehensive national information system and using the information for improved water planning and management.

26. Based on the experience from HP-I and HP-II, a four-pronged approach to achieve objectives has been adopted: (a) modernizing monitoring, including establishing comprehensive, nationwide, automated, real-time monitoring and data management systems for surface water and groundwater (both quality and quantity); (b) enhancing analytical tools for water resources assessment, hydrologic and flood inundation forecasting, water infrastructure operations, groundwater modeling, and river basin and investment planning; (c) transforming knowledge

access, using cloud computing, Internet, mobile devices, social media and other communication tools to modernize access to and visualization of customized water information by all stakeholders; and (d) modernizing institutions through investments in people and institutional capacity.

B. Project Components

27. In line with the four-pronged strategy described earlier, the project will have four components: (A) Water Resources Monitoring Systems; (B) Water Resources Information Systems; (C) Water Resources Operations and Planning Systems; and (D) Institutional Capacity Enhancement. Essentially, the data systems (Component A) will feed into the information systems (Component B) to improve planning and operations and to produce water information products (Components B and C), all of which will provide the basis for improved decision making on investment planning, water resources allocation, flood and drought management, and irrigation capacity and efficiency. Technical capacity for systems, planning, operations and policy, and decision making will be built under Component D.

Component A: Water Resources Monitoring Systems (US$150 million: IBRD = US$75 million and GOI = US$75 million)

28. This component will finance the establishment/modernization of new and existing hydromet monitoring systems including meteorology, streamflow, groundwater, and water storage measurements, and construction of hydro-informatics centers that capture both water resources and uses. This component will be implemented by all states/UTs with the support of core central agencies. The major activities will include the following:

Subcomponent A1: Hydromet Observation Networks

29. The project will establish/modernize new and existing hydromet data acquisition networks with automated/digitized and real-time communication systems. Investments will be in minor civil works for placement of sensors, installation and operation of hydromet systems for meteorology, streamflow, groundwater and water storage measurements, and portable and laboratory equipment for water quality testing.

Subcomponent A2: Supervisory Control and Data Acquisition (SCADA) Systems for Water Infrastructure

30. In addition to real-time data acquisition systems, some reservoirs, canals, and groundwater operation systems will be equipped with the remote control systems (SCADA). This will allow for remote control of gates and operation from a control room as well as allow for system response on a real-time basis during floods or other emergencies.

Subcomponent A3: Establishment of Hydro-informatics Centers

31. The facilities for automated data collection, collation, and processing at the state and national levels would be established or upgraded. The project will support (a) construction or upgrading of state and national hydro-informatics (data) centers, primarily for new states, to serve as hubs for both real-time and long-term data management and operational control systems; (b) information technology (IT) equipment and software to receive and process data; (c) services to

digitize historical data and records; (d) facilities to test hydromet instrumentation and design and provide quality control over installations; and (e) data storage servers, including cloud servers.

Component B: Water Resources Information Systems (US$50 million: IBRD = US$25 million and GOI = US$25 million)

32. Component B will support the strengthening of national and subnational water information centers with web-enabled WRISs through standardization of databases and products from various data sources/departments and make comprehensive, timely, and integrated water resources information available to decision makers for effective planning, decision making, and operations. The sources of data/information will include the real-time data acquisition networks and centers (including those acquired under Component A), remote sensing data, and topographical maps and knowledge products (including those developed under Component C). Emphasis will be on improving quality of and access to water information and on expanding public access beyond data to analytical results (trends, water balance, and so on) as well as to contribute to evidence-based operational and investment plans. An information-sharing protocol among agencies will be developed to specify which information can be publicly shared and or only among public stakeholders through secured access process.

Subcomponent B1: National WRIS

33. The web-based India-WRIS (http://www.india-wris.nrsc.gov.in/wris.html) will be strengthened through the integration of observation data systems and the inclusion of state-level data, and multidisciplinary national level information systems such as IMD, remote sensing, Survey of India (SOI), and watershed portal. It will be operated by the National Water Informatics Center (NWIC) at the MoWR, RD&GR. To facilitate the integration, the NWIC will provide support through operating environment provision, hardware, software, server, procurement and acquisition of data from other national centers so that member agencies need not to procure again. Specific activities shall include the standardization of software and protocols for database management; provision of national products/services through collaboration with other centers/organizations such as weather forecast; remote sensing-based products, and high-resolution digital terrain models.

Subcomponent B2: Regional/Sub National WRIS

34. The project will support development or strengthening of centers for web-based WRIS at the regional, river basin, and state/UT levels. The National WRIS will support regional -level WRIS though the introduction of data-sharing and data synchronization capabilities with regional data systems along with the provision of region-based WRIS views. This would thus enable seamless access to the data/information for all the member agencies. It means that a state will have access to river basin information system consisting of data provided by central agencies and other riparian states. In addition, state-WRIS views will be customized with the tools and applications to serve and exchange information with other state departments such as disaster centers, drinking water supply, rural development and agricultural departments.

Component C: Water Resources Operations and Planning Systems (US$66 million: IBRD = US$33 million and GOI = US$33 million)

35. This component will support the development of interactive analytical tools and decision-support platform that would integrate database, models, and scenario management for hydrological flood forecasting, integrated reservoir operations, and water resources accounting for improved operation, planning, and management of both surface water and groundwater (figure 1). The component will provide interactive systems to analyze the impacts of alternative management scenarios and generate knowledge products using real-time data under Component B. Component C has three subcomponents: (C1) Development of analytical tools and decision-support platform (river basin modeling, streamflow forecasting and reservoir operation systems, and irrigation design and operations); (C2) Purpose-driven support; and (C3) Piloting innovative knowledge products.

Subcomponent C1: Development of Analytical Tools and Decision-support Platform

36. This subcomponent will support development of an interactive platform for various water resources management applications, preferably web based with cloud computing. This will include developing some software applications as well as setting up the decision-making platform for actual operations and investments. The three major categories of decision tools under this subcomponent will be the following:

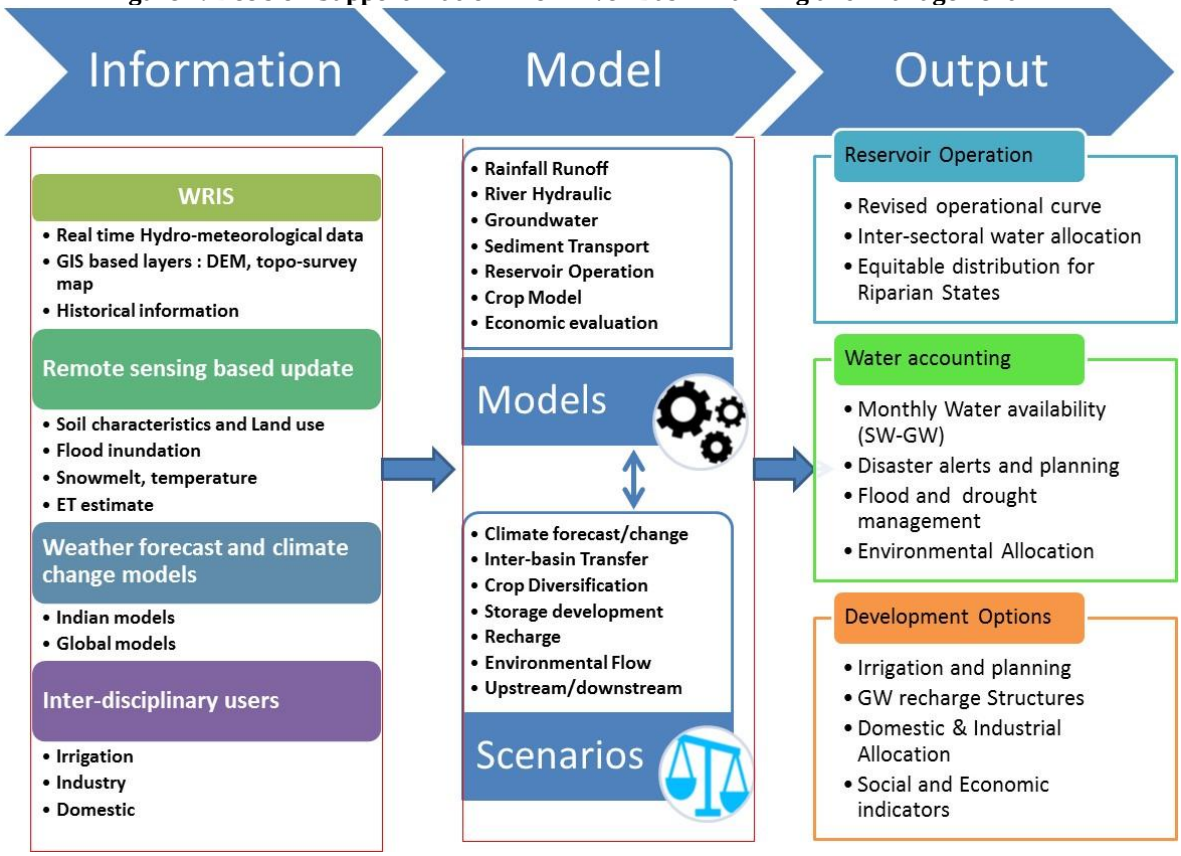
(a) **The river basin management platform** will be supported through development of a comprehensive river basin water accounting software that will enable planning and assessments with standardized procedures. The central and state/UT agencies will set up water resources budgeting systems at macro and local scales. Wherever possible, the same software and platform will be used for each basin so that the state and central models can be readily integrated. These tools will integrate all water sources/uses and will be used to plan water allocations seasonally and to operate releases from reservoirs. Detailed water resource assessments will map surface water and groundwater availability to support planned water resources development and management. This will guide the planning and design of major GoI schemes, including irrigation development under PMKSY and the preparation of water budgets and Water Security Plans under NGMIP. Knowledge products will be published through India-WRIS under Component B**.**

(b) **Streamflow forecasting and reservoir operation systems** will support integration of real-time data, weather forecast, and hydrological models for improved alert systems for disaster management. The CWC, with the support of consultants, will develop streamflow forecasting systems at the macro level integrated with real-time information and weather forecasts. These inflow forecasts will be used to manage both flood and drought by the states or the RBOs to operate the reservoirs in an integrated manner and optimize for hydropower generation, irrigation supply, and municipal and industrial water supply. Additionally, these systems will be strengthened with extended flood forecasting, climate change, and sedimentation information. Analytical tools and systems will also be developed for flood-related planning,

including flood risk mapping to guide floodplain zoning and plan for investments in hard and soft flood mitigation measures.

(c) **Irrigation management and operation system** will support improved design and operation of irrigation systems. The design of irrigation systems will be supported through the development of tools and software to improve the efficiency of hydraulic structures, including upgrade of hydrologic design aids introduced during HP-II. The smart operation of irrigation systems will be supported by the use of seasonal forecasts for reservoir operations. Remote sensing-based soil moisture and land use information will be used to match irrigation water releases to crop water requirements. Modern techniques using spatial technology will be used for benchmarking the performance of irrigation schemes.

Figure 1. Decision Support Platform for River Basin Planning and Management



Subcomponent C2: Purpose-driven Support

37. This subcomponent is expected to cover a wide range of water management issues raised by agencies—for example, issues of water quality 'hotspots', groundwater issues, or problems of reservoir sedimentation. The subcomponent will allow agencies to conduct surveys, including the assessment of social and environmental impacts. The subcomponent will also make financing available to support planning and technical investigations for investments such as the National Aquifer Program, the proposed NGMIP, the PMKSY, and other water and agricultural projects.

For instance, the NGMIP may require technical support to guide the preparation of water security plans.

Subcomponent C3: Piloting Innovative Knowledge Products

38. This subcomponent is aimed at testing innovative applications developed under the project. This may include operationalization of irrigation rosters in canal systems, piloting community-based water resources management (CBWRM) in canal water and groundwater-based irrigation systems, including benchmarking the performance of water users associations (WUAs), and other such innovative solutions. The project will support the engagement of specialized consultancies and infrastructure/goods required to put these activities in practice.

Component D: Institutional Capacity Enhancement (US$84 million: IBRD = US$42 million and GOI = US$42 million)

39. Component D aims to build capacity for knowledge-based water resources management. It will support subcomponents in the establishment of (D1) Water Resources Knowledge Centers, (D2) Professional Development (D3) Project Management, and (D4) Operational Support.

Subcomponent D1: Water Resources Knowledge Centers

40. This subcomponent will support the establishment or strengthening of 'centers of excellence' to develop expertise and a pool of experts and ensure that the knowledge, tools, and innovations developed under the project are applied to improved water resources management. The selection of knowledge center will be finalized during project implementation and might include the following centers (a) a flood forecasting center at the CWC; (b) a groundwater modeling center at the CGWB; (c) an IWRM hub at the NIH; (d) a hard rock center in Andhra Pradesh; (e) a North East Center of Excellence for Water Resources Management; and (f) irrigation management centers at selected state-run Water and Land Management Institutes (WALMIs). Where possible, knowledge centers will be co-located with the hydro-informatics centers under Component A. There will be provision for collaborating with international institutes, including twinning arrangements, and national and international academia/research centers, with support to research and internships.

Subcomponent D2: Professional Development

41. This subcomponent will aim at increasing the number of specialists in key water management disciplines where skills are lacking, both within the government and in related professional organizations and institutes. Disciplines targeted include hydrologists, water resources modelers, and river basin-based planners and managers. This subcomponent will support the development and customization of short- and long-term courses both in research and academic centers and professional training and networking among water professionals and will facilitate knowledge management and exchange as well as communications. The needs of each IA will be individually catered for, based on training needs assessments. There will be particular focus on raising the capacity of regular IA staff where hiring of new or contract staff is not possible. Training will cover the use of the models and tools developed under the project, and there will be interactive training of community groups in local water management. The project will develop

partnerships with national and international institutes, establish communities of practice, internships and visiting expert programs, launch training and workshops for knowledge exchange and professional networking, and facilitate hackathons to develop innovative water applications. An outreach and awareness program will showcase the NHP for a broad audience, both for specific target audiences such as local communities in irrigated or flood-prone areas and for the public at large.

Subcomponents D3: Project Management

42. This subcomponents will support management and facilitation of project activities at the national and subnational levels through a national project management unit (NPMU), central project management units (CPMUs), river basin project management units (RBPMUs), and state project management units (SPMUs), including technical assistance, activity management, procurement, financial management (FM), safeguards, training, communications, monitoring, learning, and evaluation.

Subcomponents D4: Operational Support

43. Operating expenses would cover the activities which are required for running the project, for example, travel expenses, boarding and lodging, incremental staff cost, rent for building, vehicles expenses, incremental office expenses like stationery, and printing.

C. Project Financing

44. The lending instrument will be an Investment Project Financing. Table 1 shows project costs and financing by component. The total project cost is US$350 million, evenly divided between IBRD and the GOI.

Table 1. Project Cost and Financing (US$, millions)

Component	Project Cost	Financing Share	
		GOI	IBRD
A: Water Resources Monitoring Systems	150	75	75
B: Water Resources Information Systems	50	25	25
C: Water Resources Operations and Planning Systems	66	33	33
D: Institutional Capacity Enhancement	84	42	42
Total	**350**	**175**	**175**

D. Lessons Learned and Reflected in the Project Design

45. Experience under HP-I and HP-II has demonstrated that institutional strengthening is complex and time consuming, involving not only investment in information and analytical systems but also development of skills and institutional capacity. The NHP will address the following additional challenges: capacity building of new states to bring them to the level of those states who participated in HP-II, expanding the focus from data collection to include data use, reforms for integrating central and state-level data, making information publicly accessible; introducing a river basin approach, including interstate data sharing and planning; and strengthening operation of systems. The activities planned under the project require significant changes from ‘business as usual’ and considerable development of institutional capacity to ensure sustainability. For these reasons, a project duration of eight years is proposed.

46. In addition to being informed by lessons learned from HP-I and HP-II, the proposed project draws on global and regional experience. International experience shows that improved access to knowledge and stronger institutional capacity can contribute to a shift toward IWRM at the basin scale. The resulting improved water allocation and use efficiency and the improved management of drought and flood risks can in turn bring substantial socioeconomic benefits. The main lessons incorporated in the project design are the following:

(a) **Water resources management requires an integrated approach at the basin scale.** Riparian states in multistate river basins need to coordinate river basin planning, particularly to optimize investments at the basin scale and to manage floods and coordinate reservoir operations. The project adopts an integrated river basin approach for water resources management.

(b) **Data need to be comprehensive, reliable, and accessible and must be available in standardized formats.** The project will modernize hydromet monitoring with reliable equipment for both automated and manual systems, web-based data storage forms and data transmission protocols, and cloud-based servers to facilitate ease of operations and maintenance (O&M) and accessibility of data.

(c) **Software must be easily available and low cost, preferably with no license fees and a web-based server.** To support large numbers of software users and wide development and use of river basin tools and DSS, the project will propose open access software with no license fees. Cloud-based computing will also facilitate large numbers of users.

(d) **Constitutional mandates for water resources management need to be respected.** The project is designed so that the center supports the states while empowering them to make their own decisions, including on procurement for hydromet, telemetry, WRISs, and flood and water resources models.

(e) **Where data are scarce and hard to collect, remote sensing is the tool of choice.** In ungauged basins and data-scarce regions, remote sensing data will be used to support basin information/assessments.

(f) **In a complex institutional environment and with a range of investments and tasks nationwide, project design needs to be flexible.** The project design recognizes that state requirements and capacities will differ. Periodic reviews will guide reallocation of resources to support changing needs.

(g) **Water sector institutional reforms require time.** Global experience indicates that such reforms are time consuming. It took more than 20 years for the European Union to have all the member countries onboard for an integrated platform. The United States is now working on a similar program toward integrating all the states as one country.

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

47. The MoWR, RD&GR will be the lead IA for the project. Implementation in each participating state/Union Territory (UT) will be the responsibility of the respective state/UT-level agencies (groundwater and irrigation/water resources department). In addition, seven central agencies and two river basin agencies will also implement project activities pertaining to their specific mandates or basin areas. Overall, there will be 49 IAs: the lead IA (the MoWR, RD&GR); 7 central agencies; 2 RBOs; and 39 state/UT agencies dealing with surface water and groundwater development and management.

48. Out of the 27 states and two UTs participating in the project, 19 states/UTs have a joint department for surface water and groundwater. These states will have one IA each. In the remaining ten states/UTs, the surface water and groundwater departments operate under different secretariats. There will be two IAs in these ten states, one for surface water and one for groundwater.

49. Implementation arrangements are based on the implementation model and lessons learned from HP-I and HP-II, where each state had one to two IAs. With the central-level IAs, this resulted in a total of 29 IAs under HP-II. The large number of IAs for the NHP is inevitable given (a) the GOI's decision to expand the geographical reach of earlier projects to cover virtually the entire nation; (b) the current institutional make-up described above (that is, with separate surface water and groundwater departments in some states); and (c) the federated structure of the GOI, where states have constitutional rights to manage water within their jurisdictions, while the central government's mandate is limited to a regulatory role and provision of technical support.

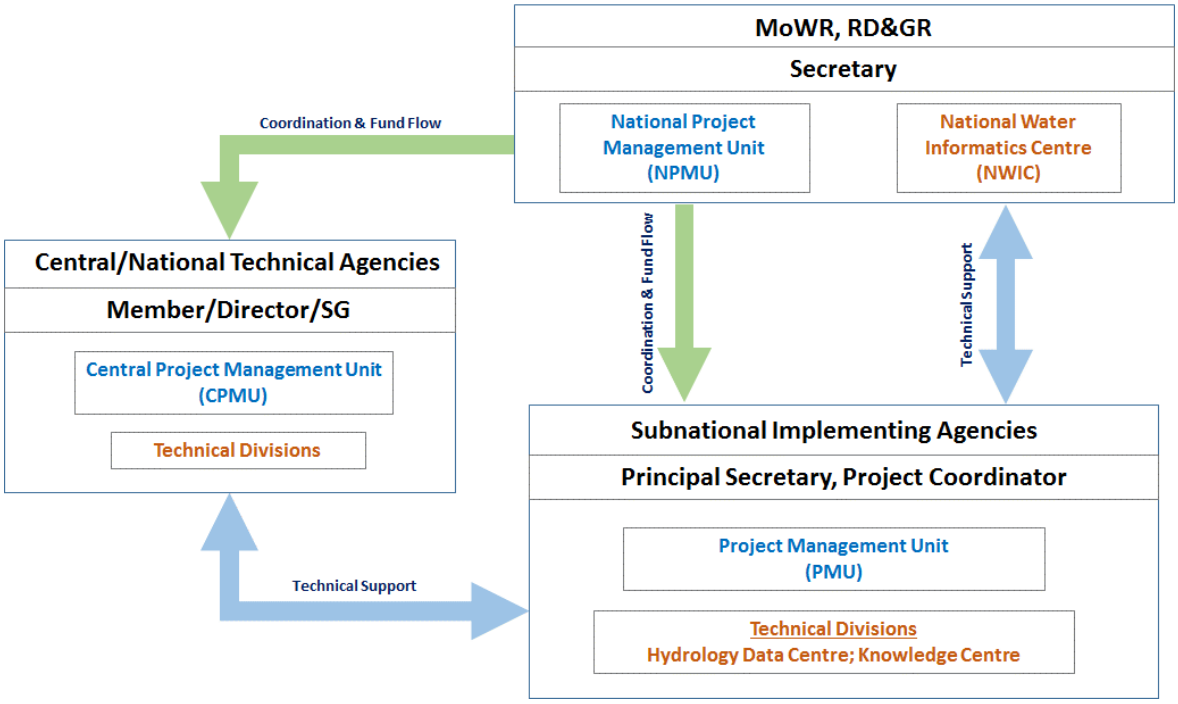
50. NHP is defined as a 'central sector scheme', where funds will be allocated to the IAs as a grant from the central government. The 'central sector scheme' is a well-established funding modality in India, used for many ongoing national programs, such as the National Rural Employment Guarantee Act Scheme and the Rural Roads Mission (*Pradhan Mantri Gramin Sadak Yojana*), among others. This is distinct from HP-I and HP-II, which were multistate loans and demonstrates the GOI's strong commitment to the objectives of the project.

51. Implementation responsibilities are distributed across the central and subnational IAs to maintain the balance and risk between centralized and state-based activities and minimize interdependence between the center and states while ensuring the integration and standardization of systems. All central and subnational IAs will have project management units (PMUs), with a multidisciplinary team required to implement project activities. Each IA will be accountable for technical, fiduciary, safeguards, and monitoring and evaluation (M&E) aspects and will have designated trained experts to perform these functions.

The implementation setup and responsibilities are summarized below and detailed in annex 3.

52. **Figure 2** provides a schematic of the implementation arrangements.

Figure 2. Project Implementation Arrangements



National Level

53. An NPMU has been established in the MoWR, RD&GR. It will be responsible for overall project planning, management, and coordination; fund allocation; financial and procurement management; monitoring safeguards compliance; M&E, including the development and operation of a management information system (MIS) and regular progress reporting to the World Bank; and communications and outreach. The NPMU will also provide technical support to subnational agencies (for example, developing standardized products) and ensure quality control. The NPMU will be guided by the National Level Steering Committee (NLSC) that will be the overarching project governing body, with planning, advisory, and strategic coordination roles.

54. The technical agencies involved in project implementation at the central level are the CWC, CGWB, NIH, CWPRS, CPCB, SOI, and the National Remote Sensing Center (NRSC). Each of the central IAs will establish a CPMU. These agencies will be responsible for the development of national-level river basin platforms, software, standards, protocols, and guidelines. They will also be responsible for providing support to the subnational agencies to introduce and apply these products at that level. In addition, the MoWR, RD&GR will establish a permanent, independent NWIC to operate and maintain India-WRIS in the long run (the NWIC is described further in annex 3). India-WRIS is currently maintained at the CWC and will be subsumed within. NWIC, which will function as an independent center. The NWIC will also support the data integration of state-level data systems and the provision of state-level WRIS views from the national WRIS.

Subnational Level

55. Subnational agencies consist of state/UT IAs, the RBOs, and the regional centers. State/UT IAs will be the water resources or irrigation departments and/or the groundwater departments.

There are two IAs at the river basin level—the BBMB and the Damodar Valley Corporation. Because the implementation of project activities cuts across various departmental divisions, the PMUs will be established in each subnational IA. Subnational IAs will receive funds from the MoWR, RD&GR and will be fully accountable for managing finances, including requesting fund releases; procurement; physical and financial progress reporting, including updating the MIS; and safeguards compliance. The subnational agencies will be supported by the NPMU and the central IAs to implement their activities, as mentioned earlier. The IAs may also hire additional technical and management expertise to meet specific needs. Similar to the arrangements at the national level, State Level Project Steering Committees will be established to provide strategic and policy direction to the state/UT IAs.

B. Results Monitoring and Evaluation

56. A results-based M&E system is being set up before the start of project implementation. The system builds on experience from the implementation of HP-I and HP-II, The system will do the following:

- Track implementation progress against the PIP and the agreed annual work programs.
- Track results against the agreed project Results Framework to measure overall results at the national level for the project as a whole and disaggregated at the level of each IA and state.
- Track the performance of each IA and state, based on progress toward the agreed results and on implementation progress.
- Carry out three major assessments of project performance, results, and emerging impacts, as inputs to the two proposed midterm reviews (MTRs) (year 3 and year 5) and to the Implementation Completion and Results Report at the end of the project implementation period.

57. Before the start of the project, an M&E cell would be established in the NPMU and M&E focal points would be appointed in each central, river basin, and state PMU (the CPMUs, RBPMUs, and SPMUs). Support would be provided by the Technical Assistance and Management Consultancy (TAMC) team. Also, before the start of the project, an M&E strategy and plan would be prepared and agreed specifying the information requirements; the tools and methodologies for data collection, analysis, and reporting; the roles and responsibilities for data collection, analysis, and reporting; the staffing, capacity building, and equipment and software requirements; and the M&E work plan for the first three years of implementation.

58. The M&E system will build on systems and baseline data established under HP-I and HP-II and will, to the greatest extent possible, be based on data being generated in the normal course of project implementation. This approach would minimize the requirement for the IAs to gather and input additional data. All data will be collected through the MIS, which will include specific modules for this purpose. All M&E data, information, and outputs will be web based and available through mobile devices. The M&E system and its outputs will provide a rich fund of knowledge. To take advantage of this, national and subnational learning forums will be convened, together

with webinars and virtual learning, and knowledge-sharing events. The MIS is already well developed and partly functional, with a number modules and training and reference material available on the web. Several sessions have been conducted to train the IAs in the MIS and they are already very actively using and contributing to it.

C. Sustainability

59. The eight-year implementation period will allow the monitoring systems to be tested and become fully operational, and the investment in agencies and capacity building under the project will construct a strong institutional basis for sustainable continuation of the systems and services set up under the project. The majority of the procurements for goods and services under the project will require comprehensive warranty and/or O&M services for 5–10 years. This will support the commitment of agencies to operate and maintain the systems in the medium-to-long term and ensure that for each agency, the system becomes an integral to their internal functioning.

60. The GOI has opted for a programmatic approach under which the project will be envisaged to support the establishment and strengthening of the systems and the MoWR, RD&GR will be expected to support the operation of those systems in the long term. The arrangement would ensure commitment of GOI to continue in the longer term.

61. The GOI has proposed to establish the NWIC to strengthen the WRIS and make it broadly accessible. It has already committed to creating 36 new posts under 'non planned funding'. The NWIC will also support the infrastructure required to maintain the WRIS, including centralized systems—database management systems, servers, dedicated telemetry systems, and so on. Under the programmatic approach, the GOI is committed to support NWIC and continue to provide water resources information services.

62. Both central and state institutions will be strengthened for the operation of core systems, including flood forecasting and river basin models. Collaboration with local/regional institutes will be encouraged so that the capacity of these institutes is also strengthened and states may continue with them as long-term partners. The project will build human and institutional capacity not only in the NHP agencies and government departments but also in academia and research institutes, so that capacity for water resources management is strengthened nationwide.

63. Integrated water resources management is important component of India's Intended Nationally Determined Contribution agreed upon in the 2015 U.N. Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21). It is also one of the nine climate adaption "missions" in India's National Action Plan on Climate Change, which outlines adaptation strategies for enhancing efficient use of water, ensuring access, and tackling the adverse impacts of climate change. The project in its entirety will provide essential support to achieving these objectives. All of the activities under the project will be contribute to mitigating both current and future climate risks, thereby generating the associated climate change co-benefits. While the project will make a significant contribution to building the country's adaptive capacity and resilience to climate change, it does not directly address mitigation. This is in accordance with India's stated policy goals for water and climate.

V. KEY RISKS AND MITIGATION MEASURES

A. Overall Risk Rating and Explanation of Key Risks

64. The overall risk rating for the proposed project is Substantial, based on the assessments provided in the Systematic Operations Risk-Rating Tool.

65. The major risks with the rating of Substantial or above are the following:

(a) **Sector strategies and policies (Substantial).** The project's success would be dependent on data-sharing policies of the ministry and states and the willingness to contribute actively to river basin assessment. There is a risk that data access restrictions and potential unwillingness of some states to share data may compromise project results. Mitigating risks related to data sharing is the central focus of the project. The MoWR, RD&GR plans to transform the current India-WRIS into the NWIC to support all IAs and provide broad public access. This includes developing standardized data-sharing protocols and facilitating data transfer. Notably, the GOI is committed to opening up even classified data and is in the process of approving government-to-government data-sharing protocols for classified data. This will serve as an incentive for states to make this data easily accessible across government agencies. To further incentivize the states, the ministry will fund states through grants. Data-sharing arrangements will be a key feature of the Memorandums of Agreements (MoAs) signed with the states.

(b) **Technical design (Substantial).** The project will develop standardized platforms for river basin planning and flood forecasting, which requires close working relations both between the relevant states and between the states and the center. There are risks in establishing collaborative exchange and partnership at both these levels. To mitigate these risks, the platforms that are to be developed will be primarily web based, which will allow for transparency and foster broader participation. The concerns addressed by these products are common ones and so there is an inbuilt incentive to participate if the products are useful and meet user needs, which is the aim of the project. A second technical risk relates to ensuring the quality and appropriateness of hydromet equipment and the system. This risk will be mitigated by empanelment of equipment makes and models and the standardization of data validation systems not only to ensure quality but also to make IAs accountable for functioning of the system. The design of the project—where states drive the process—will allow states to customize network design in accordance with state-specific requirements.

(c) **Institutional capacity (Substantial).** Variable institutional capacity across a large number of IAs, particularly for agencies in the new NHP states, may present a challenge to implementation. The multiagency risks are managed by institutional arrangements that ensure both horizontal and vertical linkages across all implementation agencies. This risk, in addition to variable institutional capacity, will also be managed by flexible planning and procurement, full technical support, and adjustable annual work programs determined by annual performance criteria. A robust

NPMU and central agencies will be supported by an international TAMC and other expert consultancies that will also provide intensive support to states. In addition, the states will be allowed to engage technical support directly. A capacity assessment of all IAs has already been conducted, which identified key gaps. During the two-year project preparation period, extensive training has taken place in technical aspects and procurement, reaching a total of 648 participants (see annex 3). Component D allocates about US$84 million to build and sustain project implementation and the technical capacity required to successfully achieve results. Two MTRs are planned to allow for adjustment of agency work plans, as well as project refocusing and reallocation of funds based on the performance of states. To strengthen the capacity of 'slow movers', additional funds could potentially be provided to support, for example, mentoring, twinning, and technical assistance. This approach was followed successfully during HP-II.

(d) **Fiduciary (Substantial).** The fiduciary risks takes into account that one-third of IAs have weak procurement and technical capacity and have no prior experience of implementing World Bank-funded projects. The rating also takes into account that fund transfers from the center to states may be slow and the necessary budgets may not be made available in a timely manner.

- Procurement-related risks will be mitigated in various ways. The center will coordinate and support large-scale procurements such as hydromet and IT services/equipment using framework-based procurement. The support to the states provided by the TAMC will also extend to procurement made at the state level. The capacity building and training were conducted during project preparation and included five focused sessions and several individual consultations on procurement-related issues (including on preparing bid documents for hydromet equipment, conducting technical and financial evaluations, and so on), which will be continued during project implementation. The modules have been made available online for reference. Procurement of several key consultancies is already under way, including the empanelment for hydromet equipment (see section VI. D on Procurement Management).

- Several measures have been or are being put in place to manage risks related to fund transfers and budgeting. The task team has worked with the NPMU to develop seamless fund flow arrangements based on the experience of other central sector schemes in India. A budget head has already been created at the MoWR for the project and allocation has been made for the current year. A Government Order (GO) has been issued by the center on the fund flow mechanism, detailing requirements for opening of bank accounts and other relevant instructions to the states. A MoA and the FM manual has been finalized, which would help them operationalize the mechanism. The NPMU will operationalize MIS-based work plans to determine and review the annual budget requirement of IAs.

(e) **Other - Coordination Risk (High).** There is a compelling case for a nationwide project with decentralized implementation to enhance ownership and ensure

sustainability. However, the approach is not without risks, including many interfaces. Implementation progress of multistate projects can be affected by various levels of government, political differences, and additional shadow control mechanisms among others. Measures to mitigate these risks include (a) extensive preparation with all states and central agencies, as described in Appraisal Summary and Annexure 3; (b) a PIP prepared by the IAs and already approved by the concerned state authorities and reviewed by the NPMU; and (c) clauses in the MoA allowing for reallocations.

VI. APPRAISAL SUMMARY

A. Economic and Financial Analysis

66. An incremental benefit-cost analysis found that the economic internal rate of return of the project is 34.8 percent. The net present value (NPV) is INR 50 billion (US$834 million) at a discount rate of 12 percent and INR 68 billion (US$1,132 million) at a discount rate of 10 percent. Sensitivity analysis was conducted to analyze the robustness of the results to variations in benefits and costs. If there are cost overruns, or the main outcomes are underachieved, the project would still be viable: a 20 percent increase in costs and a 20 percent reduction in benefits would only reduce the economic internal rate of return to 27 percent.

67. The economic and financial analysis used a modified version of the sectoral approach and combined historical data and expert opinion to estimate economic benefits. This analysis captured two main potential benefits of the NHP, which are (a) the benefits of reduced damages from flooding and (b) the benefits of better (dynamic and modeling-based) reservoir management, that is, greater hydropower generation, enhanced canal water releases for irrigation, increased drinking water supplies, and improved water supply for industrial production. Given the programmatic and long-lived nature of investments, the analysis was conducted over a 25-year period. Benefits were assumed to be generated after project completion that is, from year 9 onward. All project costs were assumed to be incurred by the eighth year. Subsequently, systems set up during the project were assumed to be operated and maintained by existing government staff and costed accordingly. Further details on the methodology and results are provided in annex 5.

68. It should be highlighted that there are several other benefits that were not included in the economic analysis because they are difficult—if not impossible—to measure and monetize. These could be substantial. For example, while the benefits generated from improved water resources operations (dam management, flood management) are included in the analysis, the likely and even larger potential benefits of improved water resources planning are not mentioned for the very simple reason that the former can be measured and monetized with a degree of confidence, while the latter cannot be measured.

B. Technical

69. Real-time data acquisition system and web-based information systems have been tested and have proved their operational feasibility and practical benefits. They were successfully established in selected states and regions, and they continue to be operational and benefit the states in their day-to-day operations. Importantly, systems have helped states to move to a more open data culture. For the majority of states, these systems will be new and there will be a learning

curve. Installation will therefore be progressive, and support and capacity building will be provided during all phases, including design, installation, quality control, and operation. To ensure sustainability, O&M will be provided for a long run-in period with the contractor, who would commission the system. The centralized support provided for database management, servers, and web-based applications will ensure the technical viability of these systems, build capacity, and ensure the interest of states to participate in information sharing, thereby, ensuring continuity. Cloud-based servers and computing will make it easy and low cost to join in data sharing, thus supporting the expansion of users and minimizing operational challenges related to hardware compatibility and upgrades. Development of river basin decision-support platforms for flood forecasting and management will be done both at the central and state levels. The uniform models approach will facilitate the integration of state models at a river basin scale. The participation of states' engineers will be ensured through various incentivized programs and posting (secondment) at the center will be encouraged.

70. The proposed technical and institutional activities are technically sound and correspond to India's top water priorities. The activities respond to demands expressed both within the central and state governments. It is expected that the project will make the following possible:

- The expansion nationwide of a real-time hydrometeorological data acquisition system will vastly increase the timeliness, reliability, and quantity of water resources information.

- Data integration among agencies and open accessibility of unclassified information will represent a quantum leap in transparent information sharing that will strengthen both water resources management and sector governance. The open accessibility of this information, shared among states, agencies, and all stakeholders, will support all aspects of water resources planning, development, and management, notably building capacity for IWRM at the basin scale.

- Dynamic water resources assessments, water accounting, and modeling at the basin scale will improve decisions on allocation of water resources and investment in infrastructure. In particular, information on spatial distribution of water resources will improve the targeting of investment and will improve the 'rightsizing' of projects.

- Integrated streamflow and weather forecasts delivered in real time or near real time will increase lead time for flood and drought warnings and allow optimal reservoir management, reducing flood risk and improving availability of water for irrigation matched to crop demand and other downstream uses.

- Improved systems for irrigation management will contribute to an increase in water availability, improved irrigation efficiency, and enhanced agricultural productivity and output.

71. The IAs will require strengthened technical capacity to implement the project, particularly in the areas of hydromet, water resources modeling, procurement, and database management. There is provision under the project to engage technical staff through central consultancies as well as state-level consultancies. Young experts will be trained through these assignments. The project

will also facilitate arrangements with academia and provide for student internships and research scholarships, which will contribute to increasing the capacity in the country. In addition, learning and sharing workshops have been organized to familiarize the IAs with global best practices and innovative tools, in particular on hydromet, groundwater-surface interactions, and sub-surface geophysics, hydrological modeling, and procurement using World Bank resources. Since September 2014, 14 training events have been organized for 648 participants, covering a range of subjects, including hydromet, hydrological and groundwater modeling, geophysics, and procurement. Details on the training events are on the project website (www.indiawrm.org) and in annex 3.

C. Financial Management

72. The Expenditure Finance Committee (EFC) project clearance outlines that the project would be a central sector scheme and would be 100 percent grant to the states by the Government of India. GOI. A dedicated budget line for the project has been created at the center. The project fund requirements at the center will be budgeted each year on the basis of an Annual Work Plan (AWP). These funds would be transferred to states as Grant in Aid. Funds would be released in tranches based on the AWP, milestones and performance of the agencies. The above arrangements are outlined in the MoA signed between the GOI and IAs.

73. As this is a central sector scheme, the funds cannot be transferred to the State Treasury and would be transferred to the IA.[6] To facilitate this transfer the IAs would be required to open a bank account in the name of the nodal officer/SPMU head[7] so that these amounts could be received and expended. MoWR, RD&GR has issued an overall Government Order/s (GO) outlining the mechanism and detailed guidelines. The states/UTs are required to open bank accounts and this needs to be authorized by their finance department. For MoWR and central agencies like CWC they would access the budget and make payments through the pay and accounts officer (PAO). For other agencies which do not access funds through budget, project funds would be transferred to project bank accounts. Each IA will follow its defined accounting and FM rules.

74. Accounting at the central and state levels will be done on a cash basis. Accounting rules will be consistent with the general financial rules applicable to all transactions of central and state governments. At the states, they will maintain separate a cash book and contract register for the project from which accounts and reports will be generated. For the MoWR and central agencies which access the budget and make payments through the PAO, the accounts would be compiled from PAO statements. For other agencies which do not access funds through the budget, the amounts would be transferred to project bank accounts through which expenditure would be carried out and statements compiled from these accounts. An Excel-based tool or Tally software would be implemented at the central level to compile and report the accounts during the first six months of project implementation. This will allow for time to pilot and roll out the MIS platform wherein the accounting reports would be captured and online reporting could be generated at central level.

[6] Central sector schemes are those schemes where the amount is spent by the center or central agencies and normally there is no provision to transfer funds to the states. So the mechanism for this project has been dovetailed keeping in view the above requirement of the center.

[7] The official who will operate the bank account would be designated by the state.

75. Disbursements will be based on interim unaudited financial reports (IUFRs). The MoWR, RD&GR will submit one consolidated IUFR within 60 days from the end of each half year, which will form the basis of disbursement from the World Bank.

76. Project activities will be subject to external audit by the office of Comptroller and Auditor General (CAG) as most of the entities are currently being audited by the Auditor General of respective states[8]. Audit reports would be tracked IA-wise and these audit reports should be submitted within nine months from the end of the financial year. In case if any entity has overdue audit reports, then their disbursements would be discontinued till the audit report is submitted to the World Bank. Audit firms at state/regional level will be hired by the NPMU to carry out internal audit of the project. Internal audit would be carried out based on the risk perceived and expenditure incurred and would be done in such a way that all agencies are covered in the audit cycle.

77. There will be a single disbursement category with 50 percent disbursement for all expenditures. Retroactive financing up to an equivalent of 20 percent of the World Bank's contribution to the project will be available for financing eligible expenditures incurred up to one year before the credit signing date.

78. Based on the present assessment, the following measures need to be implemented: (a) ensuring timely provision of budget and (b) strengthening FM capacity at the central level and hiring of FM staff at the IA level where the capacity is weak.

D. Procurement

79. Project procurement will be conducted in accordance with (a) the World Bank's Procurement Guidelines: Procurement of Goods, Works, and Non-Consulting Services under IBRD Loans and IDA Credits and Grants by World Bank Borrowers (January 2011, revised July 2014); (b) Consultant Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits and Grants by World Bank Borrowers (January 2011, revised July 2014); and (c) the provisions stipulated in the Legal Agreement. The project will be subject to the World Bank's Anticorruption Guidelines (October 15, 2006 and revised January 2011). The project procurement will be conducted using e-procurement systems for the eligible IAs (see annex 3 for details).

80. Of the 49 IAs, 36 agencies have experience of carrying out procurement under World Bank-funded projects. These 36 agencies include 27 HP-I and HP-II agencies and 9 new agencies. Out of 22 new agencies which were not a part of HP-I and HP-I1, 11 (primarily northeastern) have limited experience and exposure to World Bank procurement rules and regulations and hence, would require familiarization and capacity building. The northeastern states have demonstrated their commitment to the project, nominating dedicated teams and actively participating in project implementation. It is envisaged that each IA will be responsible for procurement and contract management for their project activities. Based on HP-II lessons, an 'empanelment list' of goods and equipment that meet the technical requirements is being drawn up and will be maintained and updated regularly at the national level. The NPMU, with support from the CWC, is the central agency responsible for creating, maintaining, and updating the list of equipment, suppliers, and manufacturers, which meet the technical requirements.

[8] Alternatively audits for entire project can be done through Chartered Accountants.

81. The Government has also indicated its wish to move from the usual practice of procurement of equipment to a new mechanism of 'procurement of data' from a service provider who would be responsible for installation of the equipment and systems and would be paid for supplying the required data. This model requires the service provider to pre-finance the capital cost of equipment and systems; install, operate, and maintain them; and recover the costs through supply of data to the Government over an extended period of time, say for six years. The financing model and procurement documents for this innovative approach will be developed and assessed after carrying out a detailed market analysis. Based on the assessment, the approach will be first tested with some potential agencies.

82. **Procurement risk assessment.** A Procurement Risk Assessment and Management System resulted in a Substantial residual procurement risk rating taking into account the proposed mitigating measures. Procurement arrangements have been finalized with due consideration to various aspects including procurement types, size of packages and capacities of IA.

83. **E-procurement system.** Procurement under the project will need to be carried out using the e-procurement systems of the IAs. The World Bank has earlier carried out e-procurement system assessments against the multilateral development banks' requirements and many state/IA systems have been approved as acceptable for use under World Bank-funded projects. There are few IA's whose e-procurement system has not been assessed; the World Bank will carry out the required assessment of the new e-procurement systems against the multilateral development bank requirements and approve the same before the IAs can start using them for procurements under the project.

84. **Procurement Plan and readiness.** The draft plan for procurement to be taken up during the first 18 months of project implementation has been prepared. The bulk of works, goods, and consultancy services has also been identified.

E. Social (including Safeguards)

85. The project is not expected to have any adverse social impacts and does not trigger World Bank Safeguard Policies Indigenous Peoples OP/BP 4.10 and Involuntary Resettlement OP/BP 4.12. The project interventions will contribute toward improving flow of information to farmers by collecting reliable data on water regime. The small and marginal farmers dependent on water resources will be able to take informed decisions. The hydromet system will be located on land, close to the banks of rivers, that is generally government land. However, a screening matrix and consultation action plan will be developed to ensure transparency in selection of land for installation of equipment. The project will support the information dissemination to the farmers and will set up a system for grievance management.

86. A broader social benefit of the project is that it will provide access for all stakeholders to the web-based WRISs. Of particular value to the general public, especially rural people, women, and farmers, will be real-time information on drought and flood, water regime, and crop water requirements (disseminated through information and communications technology platforms, community radio). A user satisfaction survey will be carried out at the start of the project, at midterm, and at the completion of implementation, for feedback from beneficiaries, with particular consideration of socially excluded groups and women, including women farmers. The survey will

provide information for further planning and corrective actions, if required. This will be an essential part of citizen engagement and beneficiary feedback processes in the project. Additionally, the project will (a) host state-level public consultations regularly during implementation, to receive feedback and use these for improving implementation and (b) publicize the World Bank's grievance redress service.

87. **Gender mainstreaming.** Under the project, training of women and the participation of women professionals in all aspects of activity implementation will be strongly encouraged and prioritized as relevant. The project will explore convergence with the National Rural Livelihood Project and the NGMIP, including the possibility of supporting the training of community-based water monitoring and management by women-led self-help groups or other water organizations (for example, water users' organizations) where women have an active presence. Other opportunities for engaging women and vulnerable groups and serving them directly or indirectly will be actively explored during project implementation.

F. Environment (including Safeguards)

88. The project triggers Environmental Assessment OP/BP 4.01 as it might cause minor potential environmental impacts arising from implementation of Components A and C. To address this, the borrower has prepared an Environmental Assessment (EA), which identifies multiple enhancement opportunities in the project and proposes ways of mitigating small negative impacts.

89. Component A that will set up monitoring stations, data centers, and associated facilities and infrastructure, may have minor construction-related environmental impacts. Construction-related impacts will be managed by application of National Building Codes in designing and construction of the small buildings and careful in situ disposal of all construction wastes. The EA highlighted the seriousness of water quality issues and the risk that water quality may be marginalized by a typical focus on quantitative measurement. As a result, Component A has mainstreamed substantial investment in augmenting water quality monitoring in the country. Monitoring of water quality and incorporation of good environmental principles in the process of preparation of basin plans have been mainstreamed in the project. The IAs have some of the requisite capacities for undertaking water quality monitoring, as well as preparing basin/sub-basin plans. Capacity gaps, with respect to analyses of water quality information and undertaking special purpose water quality studies, where relevant, have been identified, and the necessary capacity building plans are an essential component of the project.

90. Component C on the other hand, supports river basin modeling and irrigation design. If plans for infrastructure development are later based on these NHP products, there would be environmental considerations. These issues were analyzed as part of the EA, and as a result, the project design ensures that all planning and operation DSS tools, including their subsequent application, will include a process of identification and incorporation of the relevant environmental issues, such as water quality and environmental flows. The project will build or augment the capacity of agencies to develop terms of reference for preparation of basin or sub-basin plans (for water resources, flood, or drought management) and review and supervise preparation of sub-basin plans. Agencies will thus develop capability in EA and will have the opportunity to ensure that potential environmental impacts are identified, avoided, or adequately addressed.

91. The EA, including its Executive Summary, was disclosed in-country on June 16, 2016 and in the World Bank InfoShop on June 29, 2016, and can be accessed from the website of the ministry (www.mowr.nic.in) and www.indiawrm.org.

92. Overall, the project will contribute to sustainable environmental management in India and will build capacity in environmental management. Greater use of hydrological models and analytical tools based on improved data will help incorporate mainstream environmental concerns into water resources planning and management. Project investments will make it easier to collect information on environmental impacts, identify issues, and implement measures aimed at diminishing adverse effects and enhancing positive ones.

G. Project on International Waterways

93. OP/BP 7.50 on Projects on International Waterways has been triggered because the project includes activities in the Indus and Ganga-Brahmaputra-Meghna basins, which are international waterways to which the OP/BP 7.50 requirements are applicable. The project meets the exception criteria defined in paragraph 7(b) of OP/BP 7.50 and the exception was processed and approved by the Regional Vice President. Hence, no riparian notification is required as (a) the project will provide technical assistance and localized support to project implementing entities and it therefore does not involve any detailed design and/or engineering studies that may involve use or pollution of water and (b) the aforementioned activities and expected negligible impacts will not adversely change the quality or quantity of water flow to other riparian countries and will not be adversely affected by the other riparians' possible water use.

H. World Bank Grievance Redress

94. Communities and individuals who believe that they are adversely affected by a World Bank-supported project may submit complaints to existing project-level grievance redress mechanisms or to the WB's Grievance Redress Service (GRS). The GRS ensures that complaints received are promptly reviewed in order to address project-related concerns. Project-affected communities and individuals may submit their complaint to the WB's independent Inspection Panel which determines whether harm occurred, or could occur, as a result of WB non-compliance with its policies and procedures. Complaints may be submitted at any time after concerns have been brought directly to the WB's attention, and WB management has been given an opportunity to respond. For information on how to submit complaints to the WB's corporate Grievance Redress Service (GRS), please visit http://www.worldbank.org/GRS. For information on how to submit complaints to the World Bank Inspection Panel, please visit www.inspectionpanel.org. The project will also support a toll free helpline service to receive complaints for timely redressal and for tracking and monitoring purposes.

Annex 1: Results Framework and Monitoring

Country: India

Project Name: National Hydrology Project (P152698)

Results Framework

Project Development Objectives											
The PDO is to improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of targeted water resources management institutions in India.											
These results are at		Project Level									
Project Development Objective Indicators											
			Cumulative Target Values								
S. No.	**Indicator Name**	**Baseline**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**End Target**
1	Water resources monitoring stations operated by implementing agencies providing validated data online (Number)	4,370	4,370	4,700	5,900	8,200	10,700	12,000	12,900	12,900	12,900
1.a	Surface water stations (Number)	909	909	1,000	1,300	2,000	2,600	2,900	3,200	3,200	3,200
1.b	Groundwater station (Number)	2,310	2,310	2,500	3,200	4,400	5,900	6,600	7,100	7,100	7,100
1.c	Meteorology stations (Number)	1,140	1,140	1,200	1,400	1,800	2,200	2,500	2,600	2,600	2,600
2	Information products produced under the project made available to the relevant stakeholders (Number)	5	5	5	7	10	20	30	40	45	50
3	Water resources institutions achieving benchmark performance levels (Number)	10	10	10	12	14	17	20	22	24	25
3.a	Institutions upgraded to next performance level (Number - Supplemental)	0	0	0	2	5	8	10	15	20	25

Intermediate Results Indicators

			Cumulative Target Values								
S. No.	**Indicator Name**	**Baseline**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**End Target**
1	WRIS users satisfied with the services (Percentage)	0	10	10	20	30	35	40	45	50	50
2	Water data centers functioning satisfactorily (Number)	10	10	10	12	15	18	22	26	28	30
3	Page views to access the information at WRIS (Number Thousand)	400	410	420	440	470	500	520	650	780	900
4	Water availability report for river sub-basins published regularly (Number)	3	3	5	8	12	16	20	25	30	30
5	Streamflow forecasting stations with improved lead time (Number)	200	200	200	220	250	300	330	350	380	400
6	Targeted professionals trained (Number)	0	50	100	300	600	900	1,200	1,500	1,800	2,000

Indicator Description					
Project Development Objective Indicators					
S. No.	**Indicator Name**	**Description (indicator definition etc.)**	**Frequency**	**Data Source/ Methodology**	**Responsibility for Data Collection**
1	Water resources monitoring stations operated by IAs providing validated data online	This indicator measures number of stations providing accurate data for at least 80 percent of operational time. Online data will be at the centralized data center at the state or central levels. The accuracy will be validated using the database management software already available for quality control.	Annual	WRIS	NPMU/PMUs
1.a	-Surface water stations	Surface stations include stations for monitoring streamflow, water body levels, water quality, and sediments.	Annual	WRIS	NPMU
1.b	-Groundwater stations	Groundwater stations include groundwater level recorders, water quality, and tube well discharge monitoring stations.	Annual	WRIS	NPMU
1.c	-Meteorology stations	Meteorology stations include rain gauges, automated weather stations, and snow gauging stations.	Annual	WRIS	NPMU
2	Information products produced under the project made available to the stakeholders	The type of knowledge products included in this indicator includes topographic surveys, digitized maps, earth observation data products, ensemble forecast products, web-based analytical tools, forecasting materials, and water accounting reports. Information products are deemed to be made available to the stakeholders if the products is easily accessible to the relevant stakeholder (including being posted, online, mobile, disseminated through email, or disseminated in events). The relevant stakeholder is the user for whom the product is intended.	Annual	WRIS	NWIC
3	Water resources institutions achieving benchmark performance levels	Water resources institutions would refer to central- and state-level water resources departments including irrigation, groundwater, water resources department training centers, and concerned societies. Benchmark performance level would mean a score of 50% or more on a pre-defined 'Benchmark standards' which include:	Annual	NPMU will measure performance against benchmarks	NPMU

		i) Institutional Setup (25%) with required setup for modelling and monitoring and core staff in place with limited turnover; ii) Training arrangements (25%) with range of course offered, facilitates with modern training setup, trained staff and trainers developed; iii) Arrangements to provide services (50%) including reports on flood forecasting, river basin assessment, collaboration and information exchange with other institutes, ease of accessibility to tools & applications developed under the project.			
3.a	Institutions upgraded to next performance level	This indicator would provide additional information about the number of institutions upgraded against their current levels. The score obtained by institutions would be classified into 10 categories or 'notches', with each notch representing a performance level. The notches shall be categorized in a non-linear scale in order to account for baseline levels of various institutions including HP-II and new agencies.	Annual	NPMU will measure performance against benchmarks	NPMU
Intermediate Results Indicators					
S. No.	**Indicator Name**	**Description (indicator definition etc.)**	**Frequency**	**Data Source/Methodology**	**Responsibility for Data Collection**
1	WRIS users satisfied with the services	A survey will be introduced at WRIS for online users and response rated as above average will be considered satisfactory.	MTRs and ICRR	Online survey at WRIS	NPMU/NWIC
2	Water data centers functioning satisfactorily	Measures the performance of the state and national water data centers established or upgraded under Component A. Benchmark standards include the following indicators: required infrastructure for database management; trained staff; data-sharing process with center and public; and ease of access.	MTRs and ICRR	MIS, rating criteria	NPMU
3	Page views to access the information at WRIS	Number of pages views shall measure the accessibility of information systems by new and old users at central as well as state-WRIS. The baseline is for India-WRIS.	Annual	India-WRIS, State-WRIS	NWIC/NPMU
4	Water availability report for river sub-basins published regularly	Measures the number of river sub-basins (CWC definition) publishing dynamic (monthly/seasonal)	Annual	MIS	Central and state IAs

		accounting for storages, inflow forecast, and projected demands.			
5	Streamflow forecasting stations with improved lead time	Number of stations/reservoirs where flood forecast is improved with increase in lead time at least by one day. This will be primarily achieved through integration of forecast models with weather forecast and real-time data acquisition systems.	Annual	State's MIS	IAs/NPMU
6	Targeted professionals trained	Number of participants who benefit from structured training over the project period. Minimum threshold for majority of formal trainings would be 20 days in order to capture only those who are extensively trained.	Annual	MIS	IA

Note: ICR = Implementation Completion and Results Report.

Annex 2: Detailed Project Description

INDIA: National Hydrology Project

1. The GOI wishes to expand the hydrology information platform and institutional capacity established in some states under HP-I and HP-II to cover the entire country, including the states of the Indus, Ganga, and Brahmaputra basins. HP-I and HP-II, which were focused in the peninsular states of India, established improved infrastructure for water resources data collection, management and sharing, developed tools to verify water resources data, and developed and trialed tools for water resources planning and for operation of water infrastructure.

2. The NHP will improve and expand hydrology data and information systems, strengthen water resources operation and planning systems, and enhance institutional capacity for water resources management. The project will thus strengthen the information base and institutional capacity for evidence-based decision making in water resources planning and operational management at the basin scale across India using the latest technology and tools. The NHP will contribute to the GOI Digital India Initiative by integrating water resources information across state and central agencies.

3. The NHP will span both states that benefited from HP-I and HP-II investments and states that were not included in the earlier projects. In the new states, investments will be needed to move beyond existing basic infrastructure, following the approaches developed in the earlier projects. For HP-I and HP-II states, investment will focus on upgrading and completing networks. For all states, the focus will be on using the information generated for water planning and management.

4. The expectation is that knowledge, open access, and stronger institutional capacity will contribute to a shift toward IWRM at the basin scale. The resulting improved water allocation and use efficiency and the improved management of drought and flood risks are expected to bring substantial socioeconomic benefits.

A Four-pronged Strategy

5. Based on experience under HP-I and HP-II, a four-pronged strategy to achieve the objectives has been adopted:

(a) **Modernizing monitoring.** The project will establish monitoring networks in new project states, with a focus on deploying new sensors, data storage, and telemetry technologies across the whole country, to establish comprehensive, modern, automated, real-time monitoring systems for surface water and groundwater. Enhanced use will be made of powerful earth observation systems to provide improved information on water resources. Comprehensive data management systems will be further developed and deployed nationwide.

(b) **Enhancing analytical tools.** The project will develop and demonstrate tools for water resources assessment, hydrologic and flood inundation forecasting, water infrastructure operations, groundwater modeling, and river basin and investment planning.

(c) **Transforming knowledge access.** The project will build on the dramatic advances in cloud computing, Internet, mobile devices, social media, and other communication tools to modernize access to and visualization of customized water information by different stakeholders.

(d) **Modernizing institutions.** The project will complement technology investments with investments in people and institutional capacity. Support will be provided for developing centers of expertise, innovative learning approaches, collaboration with academia and research institutes, and outreach programs. Office and equipment will be modernized to streamline workflows to effectively leverage the technology investments.

Project Approach

6. **Promoting IWRM.** The project approach is driven by the need for water knowledge as the basis for meeting India's tough water challenges (refer to section I of the main text). To improve integrated management of water resources, the project is founded on the river basin approach, supporting multistate coordination for river basin planning, flood management, and reservoir operation in large multistate basins, as well as for cross-boundary aquifer management.

7. **Ensuring that information is reliable, accessible, and usable.** The project will promote accurate measurement, data checking, and validation, using standardized data storage formats and data transmission protocols and procedures, together with common data storage systems and information dissemination platforms to ensure open data access. Software systems will be generic but will allow customization to meet agency needs.

8. **Working to the strengths of India's federal system.** To foster interstate coordination within India's federal structure, the project is designed with the center as facilitator and the states as implementers. Central agencies will essentially empower the states in water management through provision of technical and financial support and will catalyze interstate cooperation on management of shared water resources.

9. **Smart support to all IAs according to their needs.** Experience under HP-I and HP-II has shown that, although all states can 'get there in the end', there will inevitably be differences of pace. The project therefore adopts a supportive, flexible approach, providing strong technical support to the states, with periodic review of support needs and of the phasing of financial resource allocation. The project will develop capacity through training, cross-learning, and collaboration among states and central agencies. Centers of excellence will be supported to establish high-level expertise that is accessible and relevant to state agencies.

Project Phasing

10. The project will be implemented in a programmatic mode where the project will support the initial establishment and strengthening of the system and the MoWR, RD&GR will support the operation of the system in the long run. The cabinet (GOI) has approved the project with an outlay of INR 36,798 million in two stages. To optimize the commitment for large sums, the World Bank funding has been matched with the stage 1 and for the activities that would require commitment

for entire project period of eight years. Based on the performance of the project and need, the additional financing will be explored during project implementation.

11. Differences in capacity and performance, particularly between those agencies which participated in HP-I and HP-II and new agencies, will be managed by adapting each agency's work plan to its capacity and support needs. Two MTRs are planned to allow for adjustment of agency work plans and to allow project refocusing and reallocation of funds. Reallocation will be based on ensuring that each agency has the funds to complete its program but spread over an implementation period matched to capacity and ensuring that adequate funds and support (mentoring, twinning, technical assistance) are allocated to strengthen the capacity of 'slow movers'.

Project Components

12. The project will support improved decision making in water resources planning and operations. This requires both improved water information and greater institutional capacity—both technical, and policy and planning capacity. Improved water information (including water resources assessments, water accounts and audits, scenario analyses and option assessments, forecasts, and early warnings) require improved water data and improved tools (analytical and DSS) to transform data into information. The project thus spans the chain from water resources data through to decision-making capacity in water resources planning and operations. This is expected to lead to improved water resources decisions (operations and planning) generating greater economic, social, and environmental benefits.

13. The project will have four components: (A) Water Resources Monitoring Systems; (B) Water Resources Information Systems; (C) Water Resources Operations and Planning Systems; and (D) Institutional Capacity Enhancement. Essentially, the data systems (Component A) will feed into the information systems and water resource modeling tools (Component B) to improve planning and operations and to produce water information products (Components B and C), all of which will provide the basis for decision making. Technical capacity for systems, planning, operations, and policy and decision making will be built under all components. Table 2.1 summarizes the component listing in the Project Appraisal Document (PAD) and cabinet note approved by the GOI.

Table 2.1. Summary of Components in PAD and in Proposal Approved by GOI Cabinet

Component	PAD	GOI Cabinet Approved
A	**Water Resources Monitoring systems**	**Water Resources Data Acquisition System**
A1	Hydromet Observation Network	Hydromet Observation
A2	Supervisory Control and Data Acquisition Systems in Water Infrastructure	Automated System Operation and Data Acquisition
A3	Hydro-informatics Centers	Hydro-informatics Centers
B	**Water Resources Information Systems**	**Water Resources Information System**
B1	National Water Resources Information System	National Water Resources Information System
B2	Regional Water Resources Information System	Regional Water Resources Information System

Component	PAD	GOI Cabinet Approved
C	**Water Resources Operations and Planning Systems**	**Water Resources Operations and Planning**
C1	Analytical Tools and Decision Support Platform	Analytical and DSS Tools
C2	Purpose-driven Support	Purpose-driven Studies
C3	Piloting Innovative Knowledge Products	Knowledge Products and Dissemination
D	**Institutional Capacity Enhancement**	**Institutions Capacity Enhancement**
D1	Water Resources Knowledge Centers	Water Resources Knowledge Centers
D2	Professional Development	Professional Development
D3	Project Management	Project Management and Technical Assistance
D4	Operational Support	Operational Cost

Component A: Water Resources Monitoring Systems (US$150 million: IBRD = US$75 million; GOI = US$75 million)

14. This component will focus on improving the extent, timeliness, and reliability of water resources data. It will finance the establishment or upgrading of new and existing hydromet data systems including meteorology, streamflow, groundwater, and water storage measurements, together with construction of data centers that capture both water resources and uses. The component, which will be implemented by all states/UTs with the support of central IAs, has three subcomponents: (A1) Hydromet observation networks; (A2) Supervisory control and data acquisition systems for water infrastructure; and (A3) Establishment of state and NWICs.

Subcomponent A1: Hydromet Observation Network

15. Subcomponent A1 will improve the extent and reliability of water resources data through automated/digitized and real-time communication systems (see Figure 2.1 and Table 2.2). The project will support installation of monitoring systems and civil works required to set up these systems. The systems could be for manual or automated measurements. Hydromet networks will encompass meteorological, hydrological (surface water and groundwater), and water quality measurements. The emphasis will be on real-time data collection and telemetric transmission for use in water resources planning, reservoir operations, and flood management. Substantial investment will be made in state and national water data centers focused on automated collection and collation, in centralized hubs for operational control systems and in water quality analysis laboratories. To upgrade the existing system, technical audit and required systems will be supported as required. Surveys of erosion and sedimentation, aquifer properties, and river geomorphology will be undertaken. A typical real-time hydromet system will include sensor/s, data logger, power source (solar/battery), and telemetry system (see Figure 2.1). The sensors will measure a range of meteorological, surface water, groundwater, and water quality parameters.

16. Meteorological equipment will include rain gauges; automatic weather stations (for temperature, relative humidity, solar radiation, wind direction, and speed); and snow level recorders and snow pillows.

17. Surface water monitoring will include monitoring inflows, storage and outflows for rivers, reservoirs, canals, tanks, and wetlands as well as monitoring of water quality and sedimentation to account for water availability (inflow and storage) and use (releases). Monitoring will primarily be by recording of water levels, with periodic comprehensive discharge measurement to establish reliable discharge rating curves. Discharge measurements will include use of traditional current meters and acoustic-Doppler current profilers. For water quality and sedimentation, some direct measurement equipment is expected, but in most cases, monitoring will require sampling for subsequent laboratory analysis. All new sites, whether manual or automated, will require civil works (for example, gauge wells, equipment rooms, cableways, and boats). River/canal water monitoring sites are categorized with a combination of parameters: water level gauge, water level and discharge (gauge discharge), sedimentation, and water quality.

18. Groundwater monitoring will include measurement of levels in observation boreholes. In India, groundwater monitoring is traditionally manual (including sampling for chemical analysis), either monthly or quarterly. During HP-I and HP-II, however, pressure transducers integrated with Global System for Mobile (GSM)/General Packet Radio Service (GPRS) telemetry proved to be successful for automated monitoring. In new project states, the density of groundwater monitoring sites will be increased, including multi-level monitoring in the case of overlying aquifers or where vertical water movement is significant. The need for additional observation wells will be partly achieved by combining pump rate monitoring of private tube wells together with automated water level recording. Portable equipment for groundwater monitoring will be procured, as will equipment for pumping tests to determine aquifer properties.

19. A range of telemetry systems will be used, as appropriate in different situations, including GSM/GPRS, Very Small Aperture Terminal (known as VSAT), and Indian National Satellite (known as INSAT) Radio. The CWC will advise the standardized telemetry system and will customize the online surface water information system (e-SWIS) software for real-time surface water data acquisition, implying that states will not be restricted to using sensor-specific software for data downloads and storage. The CGWB will also further develop and customize the online groundwater estimation and management system (e-GEMS) for real-time groundwater data acquisition. Some of the existing manual systems will be upgraded to near real-time through SMS or GPRS-enabled smart phone apps for gauge readers. The project will also explore 'crowdsourcing' of data by equipping, motivating, and training local communities for surface water and groundwater monitoring.

20. Subcomponent A1 will also improve local understanding of water resources through site-specific surveys (including river cross-section surveys, groundwater/geophysical/hydrogeological surveys, water quality surveys, and erosion/sedimentation). Support will be provided for work on geomorphology, lithology, and aquifer characteristics. It is expected that these activities will primarily be implemented through operational support for government agencies and consulting and non-consulting services.

Subcomponent A2: Supervisory Control and Data Acquisition Systems for Water Infrastructure

21. In addition to real-time data acquisition systems, some reservoirs, canal, and groundwater operation systems will be equipped with the remote control systems (SCADA) that will allow the control of gates and operation from a control room or other remote areas and, hence, allow system

responses on a real-time basis during floods or any other emergency. This will require measurement of water levels in reservoirs and offtakes (spillways and canals). Operations will be guided by the real-time measurement of water level or discharge, user demands, and forecasts made available through the DSS developed in Component C.

Figure 2.1. Schematic of Real-time Data Transfer System

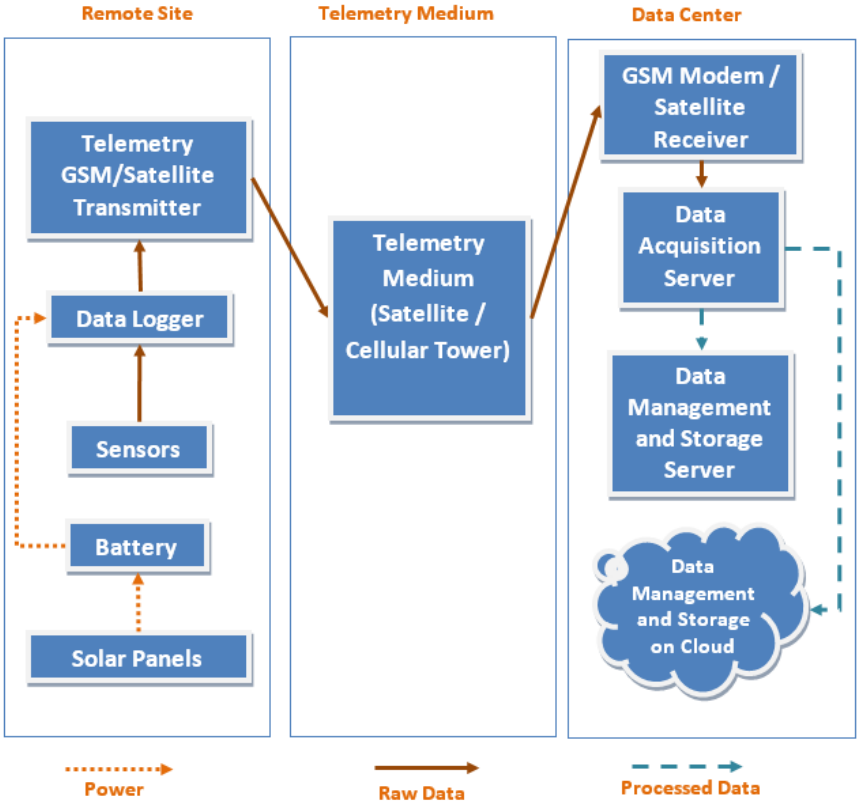


Table 2.2. Tentative Numbers of Hydromet Stations Proposed under the Project

Category	Type of Station	Number
Meteorological	Rain gauges	1,100
	Automatic weather stations	350
Surface water level monitoring	Rivers	1,300
	Dams/barrages (integrated)	650
	Canals	300
	SCADA in irrigation systems	50
	Total	**2,300**
Groundwater	Groundwater level/flow monitoring	4,800
Water quality sampling	Water quality sampling sites	1,300

Subcomponent A3: Hydro-informatics Centers

22. The project will provide infrastructure, software, and equipment for data management from automated and manual systems. This will include support for (a) construction/upgrading of hydro-informatics (data) centers (about 10 at state level and about 200 at district level) primarily for new states to accommodate staff and serve as hubs for both real-time and long-term data management

and operational control systems; (b) IT equipment and software to receive and process data; (c) services to digitize historical data and records; (d) hydrologic instrumentation facilities for testing and feasibility assessment of instrumentation, hydromet design, and to provide quality control over installations; and (e) water quality laboratories (levels 1, 2, and 2+) for water quality analysis and testing of field monitoring equipment.

Component B: Water Resources Information Systems (US$50 million: IBRD = US$25 million; GOI = US$25 million)

23. Component B will support the strengthening of NWICs and subnational water information centers through standardization of information-sharing and synchronization protocols enabling the integration of databases and products from various data sources/departments and make comprehensive, timely, and integrated water resources information available to decision makers for effective planning, decision making, and operations. The sources of data/information will include the real-time data acquisition networks and centers under Component A, remote sensing data, and topographical maps and knowledge products developed under Component C. Emphasis will be on improving quality of and access to water information and on expanding public access beyond data to analytical results (trends, water balance, and so on) as well as to contribute to evidence-based operational and investment plans. The information-sharing protocol among agencies will specify which information can be publicly shared or only among public stakeholders through secured access process.

24. The project will support synthesis publications, knowledge portals, and interactive products and services to share information and improve communications among stakeholders. Emphasis will be on improving the quality of and access to water information and on expanding public access beyond data to analytical results (trends, water balance, and so on) as well as operational and investment plans. The knowledge portals will provide easy access, facilitate training, support social media networking, and help users visualize complex information. Public access will be facilitated by a mobile-based app, and disaster-related information may also be rapidly disseminated through mobile services.

25. The project will support development or strengthening of data centers at the central, regional, river basin, and state/UT levels. The project will include support for required hardware, software, services, and collaborations and for the acquisition of additional relevant national, regional, or state data layers to minimize procurement of same data by multiple agencies. There are two subcomponents: (B1) National WRIS; and (B2) Regional WRIS.

Subcomponent B1: National WRIS

26. The NHP will fund the establishment of the NWIC, which will house India-WRIS and coordinate integration of various data and applications and cater for the needs of states. The web-based India-WRIS (http://www.india-wris.nrsc.gov.in/wris.html) will be strengthened through the integration of observation data systems and the inclusion of state-level data and multidisciplinary national-level information systems such as IMD, remote sensing, SOI, and watershed portal. Specific activities shall include the standardization of software and protocols for data exchange, database management; provision of national products/services through collaboration with other

centers/organizations such as weather forecast, remote sensing-based products, and high-resolution digital terrain model.

27. The standardization of hydrological data acquisition and processing software will facilitate streamlined data acquisition, data entry, compilation, validation, and routine analysis to enhance their quality and reliability. During HP-II, various web-based centralized database management software were developed, for entry, validation, storage, and processing of surface water (e-SWIS), groundwater (e-GEMS), and water quality information system (e-WQIS) data. These will be further developed for real-time data acquisition and with a new software/module for irrigation monitoring. The central data management software will ensure harmonized data formats, and the systems will ensure that data ownership remains with those generating the data to ensure management of data quality and access. Information sharing among agencies will be facilitated through MoAs that will specify which information can be publicly shared. These will build on protocols developed by central agencies (the IMD, CWC, CGWB, and CPCB) for interagency data-sharing, data validation, and analytical quality control procedures for water quality laboratories. Efforts will be made to improve public domain data access to stimulate the development of a wide range of products and services from the data.

28. Various national level products will include (a) generation of high-resolution topographic surveys for priority areas for flood control or infrastructure development; (b) generation of additional spatial information though field surveys, geo-tagging of various objects (water bodies, wells), and digitization of existing maps and integrating with SOI maps; (c) earth observation data products (for example, using GeoNetCast and other products) with the support of the NRSC and the CWC; (d) integration and improvement of ensemble forecast products (for example, weather, flow, flood/drought); and (e) web-based analytical tools (for example, for monitoring/forecasting various parts of the hydrologic cycle in a basin perspective, such as precipitation, snow accumulation, snowmelt, glaciers, glacial melt, glacial lakes/glacial lake outburst floods, evaporation, evapotranspiration, land use, runoff, flooding, groundwater processes, water quality, catchment water budgets, water accounting, and so on), using the available data and various spatial and temporal statistical analyses. Given the lack of metering of water use, alternative approaches such as earth observation products and/or remote sensing-based techniques will be introduced.

Subcomponent B2: Regional/Sub-national WRIS

29. The national WRIS will support regional-level WRIS though the introduction of data-sharing and data synchronization capabilities with regional data systems along with the provision of region-based WRIS views. This would thus enable seamless access to the data/information for all the member agencies. It means that a state will have access to river basin information system consisting of data provided by central agencies and other riparian states. In addition, state-WRIS will be customized with the tools and applications to serve and exchange information with other state departments such as disaster center, drinking water supply, rural development and agricultural departments, and support other schemes in the region.

Component C: Water Resources Operations and Planning Systems (US$66 million: IBRD = US$33 million; GOI = US$33 million)

30. The objective of Component C is to build on the information systems of Component B by developing and deploying interactive decision-support platforms. An interactive platform would integrate information systems and modeling tools to generate water information knowledge products and support in decision making for improved water resources operations and planning. In case additional monitoring systems are required to improve this assessment or strengthen the calibration, they will be supplemented through Component A.

31. The component will undertake a series of 'purpose-driven support' activities to fill water resource development and management knowledge gaps and develop analytical tools to support hydrologic analyses. It will allow water managers to develop cost-effective measures to address water management and environmental objectives. In particular, this component will facilitate development of tools for improved water resources assessment and flood management.

32. There will be close coordination between Components B and C on the use and generation of information systems and knowledge products/applications. Models at basin scale will be developed and applied by the CWC and the CGWB in collaboration with states and river basin IAs, using resources from the international consultancies and other high-level technical support. Models will be designed to be adaptable for use by other agencies and, in particular, will support the 'nesting' of models so that state agencies or basin organizations can develop submodels to improve the representation of local catchments within a river basin modeling system. A centralized modeling framework will be integrated into India-WRIS (or NWIC, once established) to provide an open access modeling. An 'adapter module' will allow linking of legacy models.

33. All knowledge products developed will be disseminated through Component B information systems. During HP-II, real-time operation systems were in great demand by the states. The emphasis of Component C, therefore, is on supporting agencies with improved operational systems at the reservoir and field levels.

34. Component C has three subcomponents: (C1) Development of Analytical Tools and Decision Support Platform; (C2) Purpose-driven Support; and (C3) Piloting Innovative Knowledge products.

Subcomponent C1: Development of Analytical Tools and Decision-support Platform

35. This subcomponent will support development of interactive platforms for various water resources management applications, preferably web based with cloud computing. This will include developing software applications, as well as setting up the decision-making platform to facilitate actual operations and planning. The major applications would include river basin management, streamflow forecasting and reservoir operation systems, and irrigation design and operations.

36. **River basin management platform.** This subcomponent will develop river basin models and a decision-support platform to support water resources assessments and river basin planning. This will include modeling of rainfall runoff, groundwater recharge, surface-groundwater interactions,

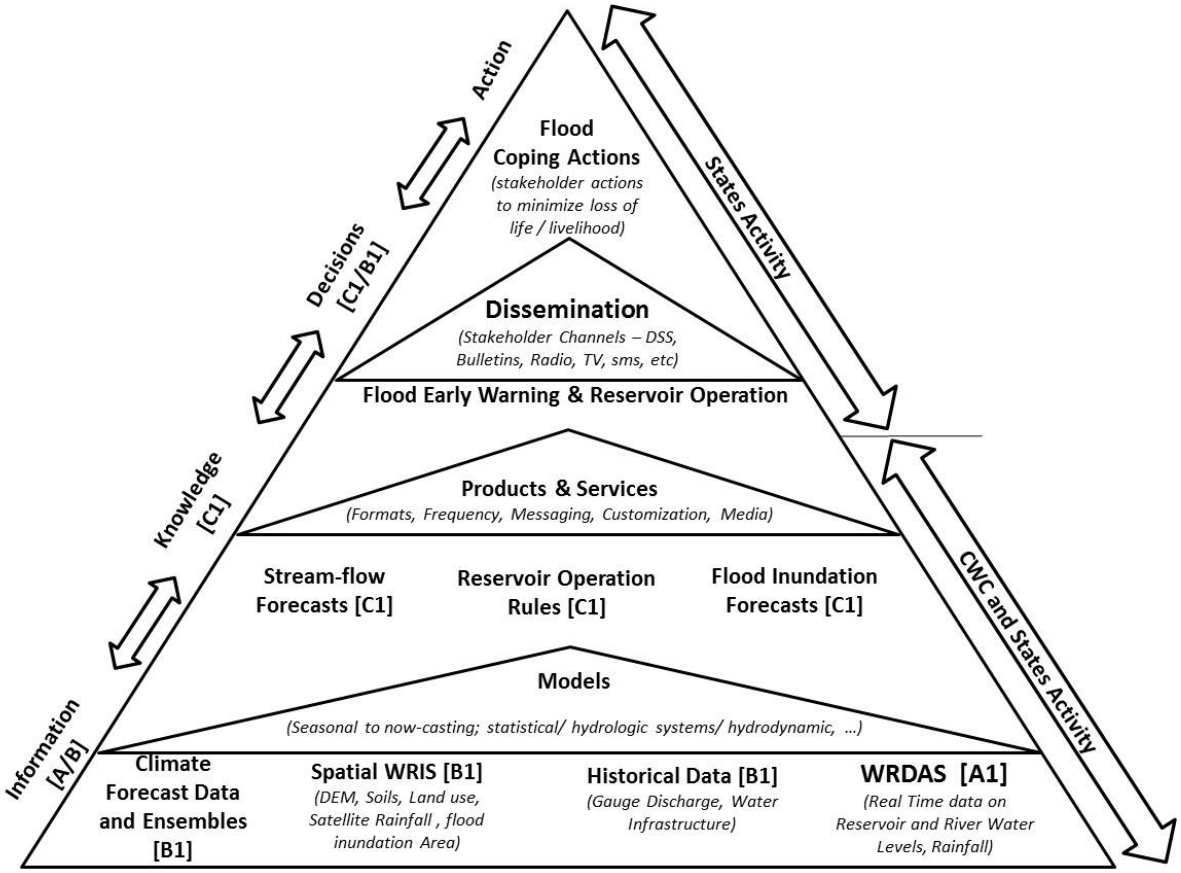
catchment erosion, water quality, reservoir operations, irrigation and drainage networks, environmental flows, future development, and climate change.

37. Central and state/UT agencies together will develop water resources budgeting tools at macro and local scales, respectively. Wherever possible, the same software and platform will be used for each basin, so that state and central models can be integrated. Existing models, where applicable, will be migrated to the same platform. These tools will integrate all water sources and uses as applicable and will be used to plan water allocations seasonally and to operate releases from reservoirs to different sectors and users with variations depending on whether the year is wet, normal, or dry. Detailed water resource assessments will map surface water and groundwater availability, which will support planned water resources development, particularly for the GOI's ambitious irrigation plans under the PMKSY (see section I), as well as evidence-based site-specific solutions. In addition, integrated surface water/groundwater models for selected hotspots will support improved planning—for example, for waterlogged irrigation projects—and will be used to assess the effectiveness of water recharge structures.

38. Various knowledge products based on water accounting at various spatiotemporal scales (watershed or basin levels and daily to seasonal) may include water availability, soil moisture status, irrigated area, crop evapotranspiration, and flood-affected and drought-affected areas. These will be published through the web portal provided in Component B both at the central (India-WRIS) and states (state-WRIS) levels.

39. **Streamflow forecasting and reservoir operation systems.** This activity will focus on development of models and decision-support interface for streamflow forecasting for flood and drought management integrated with reservoir operations. The models for streamflow and reservoir inflow forecasting will be developed by the CWC, particularly for interstate basins, using technical resources from the international consultancy and other high-level technical support. States or RBOs will integrate this forecasting tool with integrated reservoir operation systems to optimize reservoir management for irrigation supply and hydropower generation. States will be encouraged to collaborate with regional and international technical support for setting up reservoir operation systems.

Figure 2.2. Flood Forecasting System and Interactions among Project Components



40. Forecasting models (for weather, flow, inundation) ranging from nowcasting to seasonal forecasting will be included. Real-time tools and operational models will be developed to improve reservoir operations, scaling up HP-II experience with real-time decision support systems (RTDSS) (for example, for Bhakra-Beas Basin and Upper Krishna-Bhima Basin in Maharashtra). Subcomponent C1 will also develop tools for flood planning, including flood risk mapping, to guide floodplain zoning and investments in hard and soft flood mitigation measures as well as future developmental planning.

41. **Irrigation management and operation.** More efficient use of irrigation water and cost-efficient design of irrigation structures is a high priority for water resource management in India. The project will support modernization of irrigation design and smart operation of irrigation systems.

42. Modernization of irrigation design will be achieved by capacity development for the relevant divisions of state agencies, including training in the use of modern software and in use of improved hydrological information to design cost-efficient and safe structures such as rainfall intensity, duration, and frequency for design of check dams/weirs and spillways. Hydrological design aids developed under HP-II will be customized for state use.

43. For efficient operation and management of irrigation water, the project will support integrated operation of reservoirs and prepare a roster of canals based on weather/inflow forecast and actual crop critical demand. The irrigation operation systems will be strengthened through the following:

(a) **Geographic information system (GIS)/remote sensing.** Real-time information supplemented by soil moisture deficit data from satellite imagery will be used to determine reservoir releases and irrigation schedules. The NRSC has developed a preliminary system that can be developed further and introduced in pilot projects by states.

(b) **Interactive analytical tools.** The project will investigate conjunctive use of surface water and groundwater to improve irrigation efficiency and develop tools/systems for improved irrigation scheduling or similar practices.

(c) **Benchmark irrigation system.** WALMIs or equivalent state institutes will be supported to benchmark irrigation systems and to promote and monitor community-based water management. External consultants may also be recruited for this benchmarking work.

Subcomponent C2: Purpose-driven Support

44. This subcomponent will support purpose-driven studies and analytical tools to fill critical water resources knowledge gaps. The purpose-driven support program will be managed by the NIH in collaboration with IAs and supported by the TAMC. Purpose-driven support is expected to cover a wide range of water management issues raised by agencies—for example, issues of water quality 'hotspots', groundwater issues, or problems of reservoir sedimentation and environmental flows. The subcomponent will also make financing available to support planning and technical investigations for investments such as the National Aquifer Program, the proposed NGMIP, PMKSY, and other water and agricultural projects. Emphasis will be placed on the dissemination and discussion of completed studies, to ensure that these guide water resources development and management.

Subcomponent C3: Piloting Innovative Knowledge Products

45. This subcomponent is aimed at testing innovative applications developed under the project. This may include operationalization of irrigation rosters in canal systems, piloting CBWRM in canal and groundwater-based irrigation systems, including benchmarking the performance of WUAs, and other such innovative solutions. The project will support engagement of specialized consultancies and infrastructure/goods required to put these activities in practice.

Component D: Institutional Capacity Enhancement (US$84 million: IBRD = US$42 million; GOI = US$42 million)

46. Component D will build capacity and capability for the technical and planning dimensions of water resources management. Component D has three subcomponents: (D1) Water Resources Knowledge Centers; (D2) Professional Development; (D3) Project Management; and (D4) Operational Support.

Subcomponent D1: Water Resources Knowledge Centers

47. Subcomponent D1 will support the establishment or strengthening of 'centers of excellence' to develop expertise and a pool of experts and to ensure that the knowledge, tools, and innovations developed under the project are applied to improved water resources management. Although proposals are not yet final, it is expected that these centers, co-located where possible with the water data centers under Component A, will include (a) a flood forecasting center at the CWC; (b) a groundwater modeling center at the CGWB; (c) an IWRM hub at the NIH; (d) a hard rock center in Andhra Pradesh; (e) a North East Center of Excellence for Water Resources Management; and (f) irrigation management centers at selected state-run WALMIs. There will be provision for collaborating with international institutes, including twinning arrangements, and with national and international academia/research centers, with support to research and internships.

Subcomponent D2: Professional Development

48. Subcomponent D2 will provide professional training; support networking of water professionals (both technical and decision makers) nationally and internationally; and facilitate knowledge exchange, management, and communication. The subcomponent will aim at increasing the number of specialists in key water management disciplines where skills are lacking, both within the government and in related professional organizations and institutes. Disciplines targeted include hydrologists, water resources modelers, and river basin-based planners and managers.

49. The subcomponent will also support development and customization of short- and long-term courses both in research and academic centers and professional training and networking among water professionals and will facilitate knowledge management and exchange as well as communications. The needs of each IA will be individually catered for, based on training needs assessments. There will be particular focus on raising the capacity of regular IA staff where hiring of new or contract staff is not possible. Training will cover the use of the models and tools developed under the project, and there will be interactive training of community groups in local water management.

50. The project will develop partnerships with national and international institutes, establish communities of practice, internships and visiting expert programs, launch training and workshops for knowledge exchange and professional networking, and facilitate hackathons to develop innovative water applications. An outreach and awareness program will showcase the NHP for a broad audience, both for specific target audiences such as local communities in irrigated or flood-prone areas and for the public at large.

51. Formal training courses (in India and overseas), including degree and diploma courses, will cover technical and policy/planning aspects of water resources management, including hydromet networks, river basin modeling and planning, IWRM, groundwater modeling and management, remote sensing-based applications, and community-based water management. Training will be provided in the use of the models/tools developed under the project, including through degree/certification programs, study tours, workshops, e-learning tools, and distance learning.

52. At the community level, the project will identify active water management groups (WUAs) and work with them to determine the water resources information they need to manage water more effectively. Information products will be developed to meet these local needs.

53. The project will develop partnerships with well-established national and international water resources training and research institutions to support curriculum development, design, and conduct of training programs, including e-learning and distance learning. Communities of practice, internships and visiting expert programs, development assignments, international exchange programs, and membership in professional organizations will be encouraged. Support will be provided to establish communities of practice, internships and visiting expert programs, launch training and workshops for knowledge exchange and professional networking, and facilitate hackathons to develop innovative water applications.

54. The project will support workshops for knowledge exchange and professional networking, including an annual Hydrology Meeting and Expo as part of the India Water Week. Competitions will be organized to encourage exchange of skills and knowledge, to broaden awareness of water issues and tap emerging talent. These will include hackathons to develop innovative water applications.

55. An 'outreach and awareness program' will be conducted, which will showcase the NHP's purposes, activities, and products for a broad audience, both target audiences such as decision makers, politicians, religious establishments and the press, and the public at large, all of whom have a stake in improved management of water resources. A particular target audience will be local communities, particularly in irrigated or flood-prone areas where their understanding, support, and participation will be important for project implementation and results. The program will be an integral component of the NHP's implementation. Activities will include quarterly NHP newsletters, events for the celebration of World Water Day, awareness campaigns, and the preparation of videos on project achievements and lessons learned. A series of annual Indian Water Management Conferences is also envisaged. These conferences would provide a platform for practicing engineers, scientists, academia, and decision makers to come together regularly to discuss evolving water management challenges and opportunities in India.

Subcomponent D3: Project Management

56. Subcomponent D3 will support management and facilitation of project activities and will include national- and subnational-level support for technical assistance, activity management, procurement, FM, safeguards, training, communication, monitoring, learning, evaluation, and adaptive management. Subcomponent D3 will support (a) the NPMU, (b) state PMUs, (c) technical quality control for hydromet equipment, (d) monitoring and learning, and (e) governance and accountability.

57. A dedicated national PMU in the MoWR, RD&GR will provide national-level project management and develop key systems and processes for project coordination and management, including an international TAMC and establishment of an MIS. Each IA will also have a PMU. The project will support outsourced staff at state PMUs to fulfill the project management requirements according to project scope within the state. A comprehensive and robust M&E system will be established (see annex 3). The project will develop and implement a user-friendly

and responsive governance and accountability mechanism to ensure that all aspects of the project are implemented in accordance with agreed principles and procedures. This subcomponent would support incremental manpower, hiring of experts for modeling, GIS activities, field monitoring, IT support, and so on

Subcomponent D4: Operational Support

58. Operating expenses would cover the activities which are required for running the project, for example, travel expenses, boarding and lodging, incremental staff cost, rent for building, vehicles expenses, incremental office expenses like stationery, and printing.

Annex 3: Implementation Arrangements

INDIA: National Hydrology Project

A. Implementation Strategy

1. HP-I and HP-II were multistate, with individual loans/credits given to each state for execution and supported and coordinated by the MoWR, RD&GR and its central agencies. As the NHP is aimed at providing a standardized platform for integrated WRIS, operationalizing an integrated river basin approach to water resource management, capacity building, and institutional strengthening, it is appropriately conceived as a national project covering the entire country. Accordingly, the MoWR, RD&GR has proposed to introduce a 'central sector scheme,' where the ministry would fully fund the establishment of a WRIS, and it would have MoAs with the states to integrate the database. In addition, the MoWR, RD&GR will establish a permanent independent NWIC to operate and maintain WRISs in the long term. This arrangement demonstrates both central and state interest to join the NHP platform and offers several advantages, including that both the center and states will have mutual access to data and knowledge products.

2. The majority of the states and UTs have indicated their keen interest to participate, given the challenges they are facing, including with respect to climate extremes of drought and floods. The states have realized that it is impossible to manage water resources in basins which include territory in more than one state without integration at a river basin scale. The role of central agencies is critical to providing technical expertise and leadership in water resources information and water resources assessments, coordinating water management issues between states within a basin, and leading the adoption of a river basin approach to water resources management.

Strategy for Implementation Arrangements

3. The implementation arrangements for NHP take into account the following lessons from HP I and HP II: (a) national-level technical and management support needs to be appropriately staffed and flexible to match with the technical innovation; (b) in centralized procurement, state participation needs to be more effective; (c) state-level activities should not depend entirely on centralized activities—in the case of delays in centralized activities, state progress also suffers; and (d) reallocation of funds among agencies (which will be considered during the MTRs) helps to create healthy competition and incentivize well-performing states to test innovative approaches and techniques. Based on the experiences of the past two projects, implementation responsibilities have been distributed across the central and subnational IAs to achieve balanced centralized and state-based activities and minimize interdependence between the central agencies and states while ensuring the integration and standardization of systems.

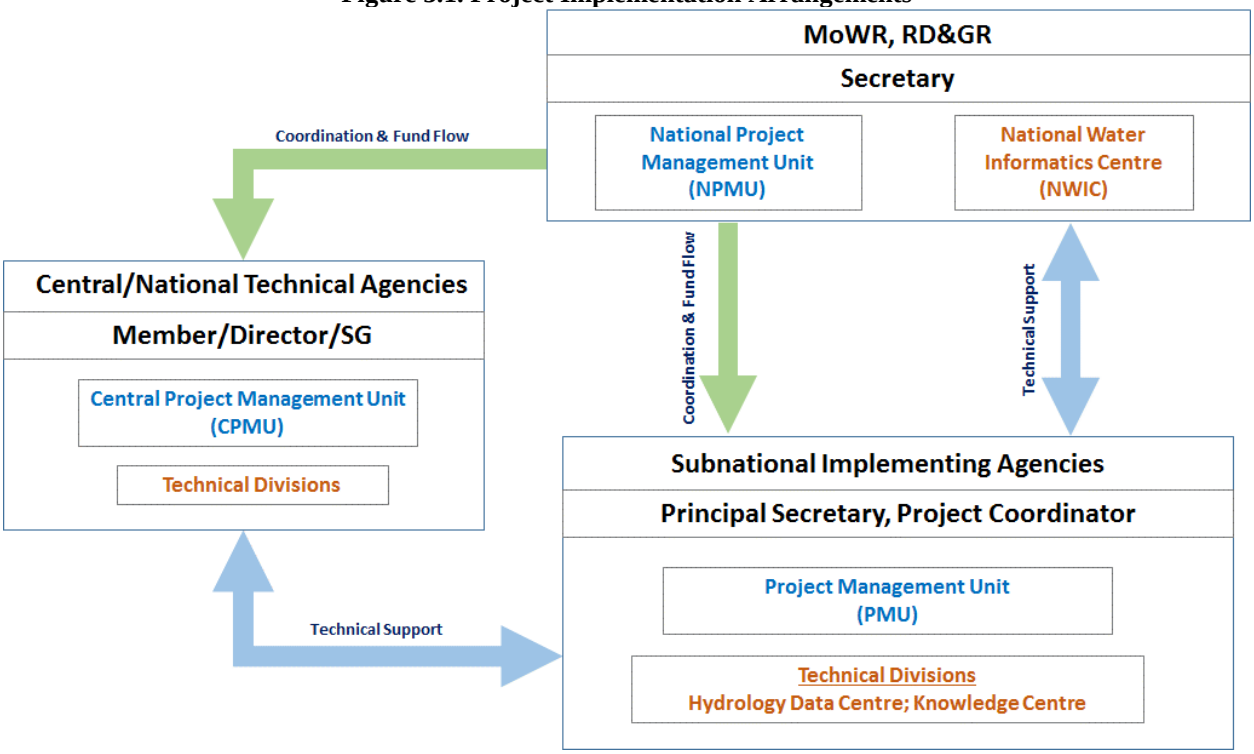
4. The MoWR, RD&GR, many of the central agencies, and a number of subnational agencies have already gained substantial experience in setting up and running hydro-informatics systems during the implementation of HP-I and HP-II. In addition, substantial implementation capacity has been built over the past two years of preparation for the NHP. Based on past and recent experience, the institutional model and implementation structure have been fine-tuned and steps have been taken to accommodate the emerging needs of integration, access, scalability, and sustainability across a larger number of IAs. These include (a) steps for mitigating the implementation

bottlenecks experienced during the implementation of earlier phases; (b) decentralized implementation, considering the field-level requirements while having balanced facilitation, monitoring, and technical guidance from the center; (c) being a centrally funded project (considering the mandated roles, responsibilities, and governance mechanisms in place); (d) special requirements for implementing an innovative and technical countrywide information system for a vital natural resource—water; and (e) evolution of implementing institutions (including virtual platforms) for realizing a long-term vision for sustainability.

5. The MoWR, RD&GR will be the lead IA, while individual IAs will be responsible for executing their own activities and accountable for agreed deliverables. Central IAs are assigned coordination and facilitation responsibilities for each project component, and each will engage consultancies to provide the required support. The central agencies will facilitate and support states to implement their activities in a number of ways, including engaging support consultancies, including a TAMC (MoWR, RD&GR); strengthening centralized database management systems, India-WRIS platform, and server (NWIC); flood forecasting (CWC); river basin planning and management (CWC); providing hydromet experts (CWPRS); groundwater modeling (CGWB); and training (NIH). The role and obligations of all IAs will be set out in the Project Agreement.

6. Variable capacity and performance, particularly between those agencies that participated in HP-I and HP-II and new agencies, will be managed by adapting each agency's work plan to its capacity and support needs. Budget allocations to each agency have been made considering the following factors: technical needs of states, varied needs of HP-II states and new states and the need to balance the capacity and requirements of new states, performance during HP-II, and size and population of the state. Two MTRs are planned to allow for adjustment of agency work plans, as well as project refocusing and reallocation of funds based on the performance of states. Any reallocations will ensure that each agency has sufficient funds to complete its ongoing program but spread over an implementation period matched to capacity. To strengthen the capacity of 'slow movers,' additional funds could potentially be provided for support—for example, mentoring, twinning, and technical assistance. This approach was followed successfully during HP-II.

Figure 3.1. Project Implementation Arrangements



Note: SG = Surveyor General

Project Management and Coordination

7. Implementation arrangements are shown in figure 3.1 above. All IAs have set up PMUs with the multidisciplinary teams. Each IA will be accountable for technical, fiduciary, safeguards, and M&E aspects and will have designated trained experts to perform these functions. Safeguards compliance will be required predominantly in northeastern states where new hydromet station sites may require land screening, and construction of new building may require both land screening and application of environmental safeguards. The concerned PMUs will designate the safeguard specialist wherever the safeguard policies should be applied.

8. **NPMU.** Following the HP-II model, an NPMU has been established in the MoWR, RD&GR. It will be responsible for overall project planning, management, and coordination across the various IAs; fund allocation; technical support; FM and procurement management; monitoring safeguard compliance; M&E, including the development and operation of an MIS and regular progress reporting; and communications and outreach. The NPMU will also provide technical support to central agencies (for example, developing standardized products) and ensure quality control.

9. The NPMU will be headed by the joint secretary (administrator) and divided into five divisions (one for each component and the fifth for administration and finance), each headed by a director. The NPMU will have a core team of 20 staff and will be supported by an internationally recruited TAMC team, with dedicated cells in each region. The TAMC team will be multidisciplinary and will consist of senior managerial and technical specialists, including

hydromet, water resources management, institutional, social and environmental, finance and procurement, and program management specialists. The TAMC will provide intensive support to the states through the regional cells, but state agencies will also be able to hire additional technical and management consultants for their specific needs. The NPMU will have a dedicated fiduciary desk to streamline the fund releases and will arrange audits to ensure the processing of claims on time.

95. The NPMU will be guided by the National Level Steering Committee that will be the overarching project governing body, with planning, advisory, and strategic coordination roles. The NLSC will be chaired by Secretary, MoWR, RD&GR with Additional Secretary; representatives of central agencies & RBOs and Principal Secretaries of implementing states as members and Joint Secretary (Admin) MoWR, RD&GR as Member Secretary.

Project Implementation

10. **Central-level technical support.** There are seven central IAs: the CWC, CGWB, NIH, CWPRS, CPCB, SOI, and NRSC. These agencies will be responsible for the development of national products (software, river basin decision support platforms, standards and protocols, and guidelines) and for providing support to the subnational agencies to introduce and apply these products. Each of the central IAs will establish a CPMU with a multidisciplinary team (including fiduciary, safeguards, and M&E experts). Each CPMU will coordinate with the respective agency's internal divisions to execute activities assigned to it and ensure project guidelines are being followed.

11. The central IAs will be responsible for validating data and providing standardized applications and procedures in their respective domains. For example, the CWC will empanel the make and models of hydromet systems; the CWPRS will provide support in hydromet design, installation, and quality control; the IMD, CWC, CGWB, and CPCB will validate the data for their respective domains; and the SOI and NRSC will support in consolidating topographical surveys and remote sensing information, including providing quality control. Some states have also partnered with the NRSC and state remote sensing centers to launch state-WRISs. The IAs will hire consultancies to assist them in performing their respective activities. For example, the CWC will have time-based consultancies to support river basin water resources assessments, and states will have the option to extend their services for detailed assessment of their respective basins or engage the expert consultancy on their own. Of the seven existing central IAs, two agencies (NRSC and SOI) are new to the NHP, although they have experience with World Bank procedures. Some of the divisions at these central agencies will be upgraded to 'centers of excellence' for learning and exchange, equipped with modernized infrastructure and facilities and attracting international expertise and/or establishing collaborative arrangements with international organizations.

12. India-WRIS is currently being maintained at the CWC. The system and the team will be shifted to the NWIC at the MoWR, RD&GR—to be established under the project—to ensure the integration and exchange of data among all sectors (agriculture, environment, fisheries, drinking water, inland waterways, power, and so on). The NWIC will be responsible for collecting and collating hydrologic data from across the county, conducting preliminary processing, and maintaining all data in an open format and transparently on a GIS platform. The NWIC will, thus, effectively serve as a repository of nationwide water resource data. It will also support the

development of state-WRISs. The ministry will fully fund the establishment of the WRISs, and it will have MoAs with the states to integrate the database. It is planned to set up the NWIC in New Delhi as an independent organization under the overall supervision of the secretary (MoWR, RD&GR) and with representation from other relevant ministries. The NWIC will be headed by the joint secretary, the MoWR, RD&GR, and several multidisciplinary posts (29) have been created, which will be filled by technical staff deputed from the CWC, CGWB, and NRSC. These posts have been created under the 'non-planned budget' category and, as such, will continue after project closure. This arrangement demonstrates both central and state interest to join the NHP platform and offers several advantages, including that both the center and states will have mutual access to data and knowledge products.

13. **Subnational level.** Subnational-level IAs consist of state/UT IAs, RBOs, and regional centers. State IAs will be the water resources or irrigation departments and/or the groundwater departments. Because the implementation of project activities cuts across various departmental divisions, SPMUs will be established, preferably in the hydrology center/division where one exists—HP-I and HP-II states have established hydrology data centers or dedicated hydrology divisions and PMUs have been established within them. In new states, the IAs have nominated SPMUs with critical staff. Only around 50 percent of agencies in new states have a division for water resources measurement, while northeastern states do not have any arrangement for hydrological monitoring, meaning that these states will be required to strengthen the respective division or establish a dedicated cell following the central structure of the NWIC.

14. Each SPMU will be headed by a chief engineer and will have procurement and technical experts from government staff (hydrology data center or equivalent), as well as IT staff on contract basis. Each SPMU will be staffed with a multidisciplinary team, including in FM, procurement, safeguards, and M&E. The SPMU will be supported by the NPMU/TAMC team and the central IAs, as mentioned above. State IAs may also hire additional technical and management expertise to meet specific needs. Numerous training events have already been conducted to begin the process of capacity building to level the playing field across state IAs (in particular, those that did not participate in HP-I and HP-II). In addition, well-performing agencies from HP-II will mentor new IAs.

15. **Regional/RBOs.** There are two IAs at the river basin level—BBMB and Damodar Valley Corporation—and one regional organization is planned to be established under the project—the North East Center of Excellence for Water Resources Management. Eight northeastern states have proposed to establish the North East Center of Excellence for Water Resources Management, which would serve as the technical hub for the northeast region, including operating applications for regional basins. These subnational IAs would be responsible for executing targeted activities in light of the common challenges and extent of needs in the region. In particular, a flood forecasting system will be operated through the North East Center of Excellence for Water Resources Management. Similar to state agencies, the subnational IAs will be responsible for the implementation of project activities and will have PMUs established for this purpose, with all the required expertise.

16. Subnational IAs will receive funds from the MoWR, RD&GR and will be fully accountable for managing finances, including requesting fund releases; procurement; physical and financial progress reporting, including updating the MIS; and safeguards compliance. The subnational IAs

will be supported by the NPMU and the central IAs to implement their activities, as mentioned above. The IAs may also hire additional technical and management expertise to meet specific needs. Similar to arrangements at the national level, state-level project steering committees will be established to provide strategic and policy direction.

B. Component-wise Implementation Arrangements

Component A: Water Resources Monitoring Systems

17. This component will be implemented by all subnational IAs and selected central agencies (**Table 3.1**). The major activities under the component are commissioning of hydromet systems and construction of data centers.

18. The hydromet system (particularly surface) will differ from state to state. The design and selection of instrumentation will be supported by the CWC and TAMC experts, building on the intensive training over the past two years that has been provided to all the state engineers, as well as the training material and manuals that are available on the project website (www.indiawrm.org). Procurement of hydromet equipment will include procurement of equipment and integrator services and procurement of data services with a long-term (10 years) commitment. During HP-II, state engineers had difficulties with technical evaluation (during procurement) and in contract management (during installation). To address this issue, a Hydromet Specifications Committee will facilitate technical evaluations through the short-listing of makes and models of monitoring sensors/components and standardization of specifications. The CWC will process the empanelment of equipment makes and models and simplify technical evaluation. The states will be required to use a simple procurement document for financial bids for hydromet supply and installation. The rates for the telemetry system will also be standardized through central procurement services, and states will procure from recommended providers. The CWPRS will provide support during selection and installation and for quality control of hydromet equipment. The quality control and validation of data will be conducted by the respective central agencies through the software supported under Component B. The CWC (e-SWIS), CGWB (e-GEMS for Digital Water Level Recorder), and CPCB (real-time water quality stations) will configure online database management systems for real-time data acquisition to avoid recurring charges for software by individual vendors, as experienced in earlier projects.

Table 3.1. Technical support roles of Central agencies for component A: Water Resources Monitoring Systems

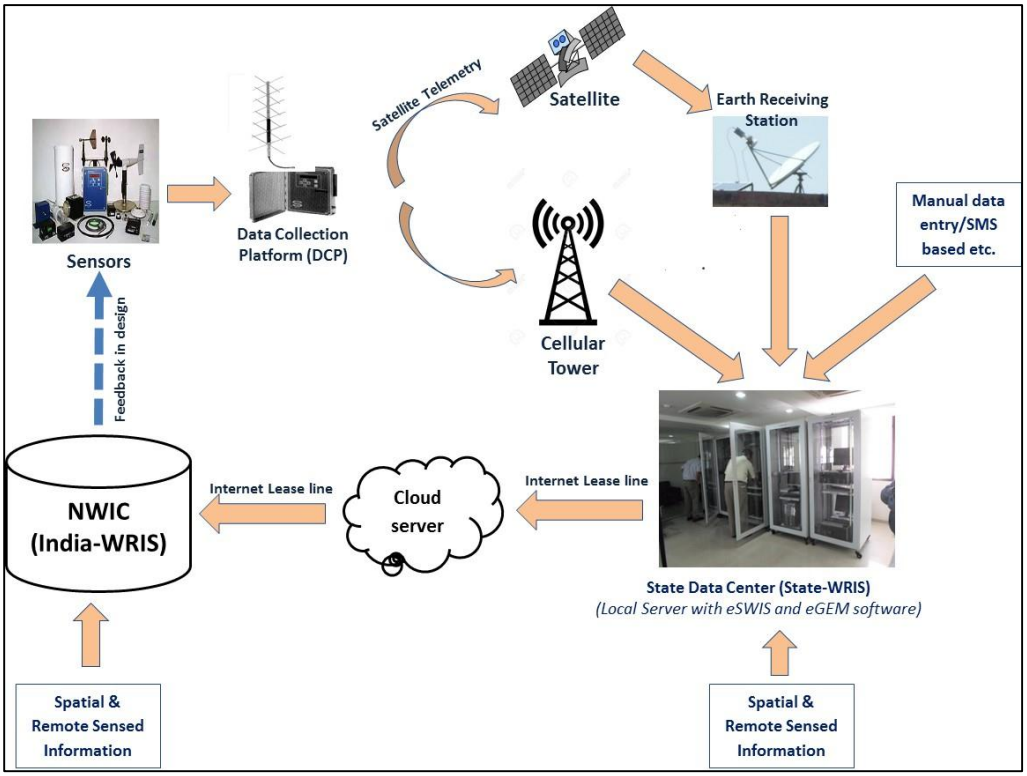
Technical Task/Role	Agency
Overall coordination and technical guidance responsibility	
Surface hydrology	CWC
Groundwater hydrology	CGWB
Water quality	CPCB
Optimization of hydromet design and training	Central domain expert agencies and (NIH)
R&D for instrumentation	CPWRS
Third-party QA/QC	NPMU/CWPRS
Specific technical tasks	
Hydromet specifications	Hydromet Specification Committee
Empanelment of hydromet equipment	CWC
Online storage and data display on WRIS	NWIC

Technical Task/Role	Agency
Overall coordination and technical guidance responsibility	
Data backup and archiving	Central agencies with cloud server and all agencies
Telemetry empanelment/arrangements	CWC/NPMU
Standardization and validation of online database management systems	
e-SWIS	CWC
e-GEMS	CGWB
e-WQIS	CPCB

Note: CPWRS = Central Power Research Station; QA = Quality Assurance; QC = Quality Control; R&D = Research and Development.

19. The CWC will organize centralized satellite-based hubs and will customize e-SWIS software for real-time data acquisition. States will be free to have an independent e-SWIS server or to be integrated with the CWC system (see figure 3.2). The CWC has a cloud server with the facility to provide a dedicated storage system for all agencies. Considering long-term O&M requirements, this arrangement may suit many states as it avoids state-level financial liability.

Figure 3.2. Real-time Data Transmission System in State and Center using Satellite Technology



Component B: Water Resources Information Systems

20. The success of this component will rely on cultural change in agencies to effectively contribute to the sharing and integration of data. The NWIC with the MoWR, RD&GR will anchor this component in India-WRIS. The ministry will have a key role in setting protocols through

issuance of MoAs for data sharing at various levels, including government-to-government and online for research organizations and the general public. Some states need to align their data dissemination policy with the central policy, particularly southern states, which have a data-sharing policy that is inconsistent with the National Hydrometeorological Data Dissemination Policy that advises publishing data on India-WRIS. The CWC, CGWB, and CPCB have already posted a large amount of data online. Upgrades of the e-SWIS and e-GEMS software for managing surface water and groundwater data storage, data validation, and data archiving will be critical early activities, followed by extensive training for other users of the systems within the states. Development of India-WRIS will be led by the NWIC, which will also facilitate and assist the states wishing to develop their own subsystems. Procurement of additional data sets for WRIS systems will be coordinated and supported by central agencies. Some state agencies have already collaborated with the NRSC and state remote sensing centers or equivalent to initiate state-WRIS.

Table 3.2. Technical support role of central agencies for of Component B: Water Resources Information Systems

Technical Task/Role	Agency
Lead implementation agency for India-WRIS	NWIC
Standardized database management systems	CWC, CGWB, and CPCB
India-WRIS standards and protocols	NWIC, CWC, and NRSC
Mapping services and DEM	SOI
Real-time remote sensing applications	NRSC
MoA for data-sharing protocols and monitoring	NPMU
Development of India-WRIS	NWIC
Support to states to develop regional WRIS	NWIC and NRSC
Development of state-WRIS	State agencies to collaborate with competent agencies in the state
Collaborate with other state departments	State agencies

Component C: Water Resources Operations and Planning Systems

21. This component will have three major activities: flood forecasting, river basin accounting, and irrigation operation systems. The CWC will coordinate the modeling element of this component with the help of the international consultancies (Table 3.3). The CGWB will contribute to the groundwater modeling work. The international consultancies will support an integrated river basin approach, including flood forecasting, streamflow prediction, and water resources assessment at river basin scale. State agencies will assign modeling teams to work with the CWC and to establish this approach within their state with the help of centralized experts or agencies engaged directly by them.

22. The majority of states lack capacity to establish and operate advanced flood forecasting systems. The CWC has the mandate to forecast flooding, as requested by states. The CWC will engage a consultancy for the entire country that will set up the model on a single platform. The consultancy will also upgrade existing models. Streamflow forecasting will be provided by this consultancy to the states; in the cases where states or other IAs (for example, NRSC) already have established streamflow forecasting, the systems will be integrated with the centralized platform. The reservoir operation systems (primarily for HP-II states) will be set up by the states' IAs or RBOs with the support of consultancies engaged for this purpose.

23. To conduct water accounting, states will explore various options including extending the scope of consultancy engaged by the CWC and hiring them directly, engaging a separate consultancy, strengthening the WRIS team on hydrological modeling and water resources accounting under the guidance of NRSC and CWC, and collaborating with training institutes to conduct longer-term training programs that would build the capacity of engineers. Whatever the modality, the objective would be to update water use data and conduct water accounting for sub-basins, while the CWC would integrate this information for all interstate basins.

24. The NIH will coordinate and provide technical support for purpose-driven support under Subcomponent C2.

Table 3.3. Implementation of Component C: Water Resources Operations and Planning Systems

Technical Task/Role	Agency
Flood forecasting and river basin assessment models	CWC and CGWB with state IAs
Training and expert support to river basin modeling	NIH
Scoping and coordination of the purpose-driven support program and provision of technical support	NIH
Groundwater modeling	CGWB

Component D: Institutional Capacity Enhancement

25. The NIH will be the coordinating agency for all training, with support from central technical assistance consultants (table 3.4). They will coordinate training on tools developed under the project and will develop additional training programs—in particular on hydromet systems, river basin modeling, and groundwater modeling—in association with reputed national and international institutes. The MoWR will take the lead in signing MoUs with key national and international institutes; other agencies will be covered automatically under the MoU, allowing them to customize their programs. The NPMU will coordinate collaborations with international institutes and will advise on staffing and institutional arrangements for centers of excellence proposed under the project. States may also develop specialized courses through direct collaboration with established national and international institutes.

Table 3.4. Implementation of Component D: Institutional Capacity Enhancement

Technical Task/Role	Agency
Collaboration with international organizations	NPMU (MoWR, RD&GR)
Advice on setting up centers of excellence	NPMU (MoWR, RD&GR)
National and international training	NIH with TAMC team
Overall project management, M&E, FM, and safeguard	NPMU

C. Assessment

26. Of the total 39 state/UT IAs, 39 have already established hydrological monitoring divisions (see table 3.5). The six northeastern states (except Nagaland) are yet to establish hydrology divisions. New agencies will establish hydro-informatics cells, initially to facilitate project implementation and subsequently to fulfill an ongoing role in collection, collation, and sharing of hydromet data and information. Each hydro-informatics cell will consist of a project coordinator

for overall leadership and a project nodal officer for day-to-day operations, assisted by a core team, the size of which will depend on the scope and size of the technical program.

Table 3.5. Assessment of IAs

Type of Agencies	Number	HP1 and HP2 IA	Agencies with Existing Hydrological Monitoring Divisions*	Agencies Experienced with World Bank Procurement
State	37	19	31	25
UT	2	1	1	1
Central	8	6	5	8
RBO	2	1	2	2
Total	49	27	39	36
Percentage of total*			80	73

Note: * Percentage represented with respect to total state agencies.

27. The 20 HP-II IAs have established appropriate institutional arrangements but can further improve these and streamline implementation arrangements, particularly for irrigation/reservoir management. Among the 22 new agencies, 11 are familiar with World Bank procurement while 11 (primarily northeastern) will require familiarization.

28. Since 2014 the World Bank and the GoI have organized fourteen various learning and sharing workshops with over 600 participants to familiarize IAs with global best practices and innovative tools—in particular, on hydromet, groundwater, surface and sub-surface geophysics, hydrological modeling, and procurement.

D. Results Monitoring and Evaluation

Four-track Results-based NHP M&E System

29. Building on systems and experience under HP-I and HP-II, a results-based NHP M&E system will be set up before the start of project implementation. The system will work on four complementary tracks:

- **Track 1: Monitoring implementation progress.** This track will monitor implementation progress (activities and inputs) against the PIP and the agreed annual work programs. The parameters to be tracked will include (a) activities and inputs delivered; (b) procurement progress; (c) financial progress; and (d) quick institutional performance indicators such as staffing against complement and training days. The information will be disaggregated at the level of each IA and state and aggregated at the national level for the project as a whole. The information will be used by IAs to monitor implementation progress at their level and by decision makers, supervisors, and other stakeholders to ensure timely and quality implementation and to allow corrections and troubleshooting.

- **Track 2: Results monitoring.** This track will monitor results against the agreed NHP Results Framework (annex 1) to measure overall results at the national level for the project as a whole and disaggregated at the level of each IA and state. The information will be used by IAs, decision makers, supervisors, and other stakeholders to follow overall project performance against agreed results on a regular basis during implementation and at completion.

- **Track 3: Institutional performance monitoring.** This track will monitor the performance of each IA and state, based on institutional performance against benchmarks as well as progress toward the agreed results and on implementation progress. The information will be used to track the performance of each IA to (a) ensure adequate support and help in correcting anomalies and troubleshooting and (b) ensure that appropriate financial resources are allocated to each state program. The information will be used by IAs to monitor their own performance and identify needs for support and by decision makers, supervisors, and other stakeholders to identify needs for institutional strengthening as they arise. Performance will be monitored on a regular periodic basis (twice a year), with decisions on reallocation of project financial resources agreed and formally decided based on the two MTRs.

- **Track 4: Interim and final evaluations.** This track will comprise three major assessments of project performance, results, and emerging impacts, as inputs to two proposed MTRs (year 3 and year 5) and to the Implementation Completion and Results Report at the end of the project implementation period (year 8). The assessments will summarize information from the three monitoring tracks described above and add a fourth track, which would assess (a) emerging impacts based on user feedback and demonstrated benefits from changes in operations and planning resulting from the project and (b) institutional performance and sustainability. The information will be used by IAs, decision makers and supervisors, and other stakeholders to (a) evaluate progress toward achievement of the PDO based on the interim and final results; (b) assess the efficiency of implementation; (c) gauge the likely sustainability of outcomes; and (d) assess performance of IAs, the GOI, and the World Bank.

Implementing Monitoring and Evaluation

30. This results-based M&E system will be founded on (a) the agreed Results Framework; (b) the parameters set out in the PIP and specified for each IA and for the project as a whole in the agreed annual work programs; (c) agreed areas of expected outcome and benefit as evaluated in the project economic analysis (that is, reduced flood damage, increased hydropower generation, and increased water availability for irrigation, drinking water, and industrial water supply); and (d) agreed institutional performance and sustainability criteria. Indicators and baseline data will be established for each parameter to be tracked.

31. An M&E cell is being established in the NPMU. M&E focal points are being appointed in each central, river basin, and SPMU (CPMUs, RBPMUs, and SPMUs). An M&E strategy and plan for the first three years of implementation will be prepared with the help of the TAMC team which

will include organization of information required for Results Framework; the tools and methodologies for data collection, analysis, and reporting; the baseline data required; the roles and responsibilities for data collection, analysis, and reporting; the staffing, capacity-building, and equipment and software requirements.

32. At the outset, the NPMU with the TAMC team would conduct information and training of (a) managers to inform them of the system, its value, and how to use the M&E reports in the course of implementation and (b) other staff responsible for MIS and M&E to ensure that data requirements and sources are understood.

33. The M&E system will build on systems and baseline data established under HP-I and HP-II and would, to the greatest extent possible (target 100 percent), be based on data being generated in the MIS in the normal course of project implementation. This would minimize the requirement for IAs to gather and input extra data. All M&E data, information, and outputs will be web-based and available through mobile devices.

E. Financial Management

34. The FM risk is rated as 'Substantial'. The paragraph below describe the various FM arrangements.

Budgeting

35. The project will be a 'central sector scheme' with 100 percent grant to agencies. The GOI has created a separate budget line for externally aided project, NHP, and budget allocation has been made for the current fiscal year. Budgets will be prepared based on the approved AWP, which in turn will be prepared based on project needs, implementation capacities, and past performance. The timelines for preparing and submitting the AWP and the budget request are outlined in the FM Manual, which needs to be adhered by all the IAs.

Fund Flow Arrangements

36. As this is a central sector scheme, funds would not be transferred to the state treasury but would be transferred to the IA. To facilitate this transfer, the IAs would be required to open a bank account in the name of the nodal officer/SPMU officer so that these amounts could be received and expended. The MoWR, RD&GR has issued an overall GO outlining the mechanism, and detailed guidelines are outlined in the FM Manual. The NPMU will remain within the existing FM systems of the MoWR, RD&GR. No separate bank accounts will be established for the NPMU. All transfers would be made through the PAO to the IAs.

37. The MoWR, RD&GR will release funds to state and central IAs as per MoAs, which [have been] signed between the MoWR, RD&GR and each participating state and central IA. Funds will be released in two tranches each year through direct transfers into IAs' bank accounts. For all fund releases following the first tranche, the state and central IAs will be required to submit documents as outlined in the MoA. Fund flows to the state and central IAs will be based on actual expenditure and contractual commitments of the IAs. The milestones for release of payments are outlined in table 3.8.

Table 3.6. Annual cycle of Installments from the MoWR, RD&GR to IAs

Tranche	Period	Conditions of Release
First (up to 60 percent of the AWP)	April–May	• Approval of the AWP and Annual Procurement Plan • On fulfilling condition(s) imposed at the time of release of previous tranche • IUFR for the previous half year and utilization certificate for the previous period • Audit report for the previous financial years, which are due before the tranche is requested
Second (balance of the AWP)	October–November	On the request of PMUs of all IAs, in prescribed pro forma and on fulfilment of the following conditions: • Utilization of at least 60% of the total available funds (including opening balance) and submission of utilization certificates • The opening balance of the PMUs not to exceed 10% of the allocation of the previous year; central funds would be proportionally reduced for unutilized amount • Audit reports for the last fiscal year (with auditor's remarks) • Utilization certificates and bank reconciliation statement for the previous year furnished along with nondiversion of fund certificate • IUFR for the previous half year • Achievement with reference to AWP • Other terms and conditions stipulated at the previous release having been met

Accounting and Information System

38. Each type of agency has its own accounting and FM rules defined and follows them. The accounting at central ministry and state implementing levels will be done on a cash basis using government accounting systems, and expenditures will be recorded against the allocated budget. Accounting will be guided by general financial rules, as applicable to all transactions at the GOI/state levels. Adequate accounting records will be maintained for project transactions.

(a) **Accounting at departments.** The departments will maintain cashbooks and other relevant ledgers[9] for the project separately for the ease of accounting, auditing, and reporting. The departments would report the expenditure in the IUFR formats. All accounts from the departments would be consolidated and collated at the SPMU, and the accounts would be sent to the MoWR, RD&GR in a prescribed format.

(b) **Accounting at central agencies.** These agencies will follow the accounting system normally used by them and would maintain separate cashbook and accounts for the project along with a separate project bank account. These agencies would submit the accounts and reports to the MoWR, RD&GR for consolidation. Some of the agencies would have access to the budget, in which case, all payments would be made through PAO and accounts would be available from PAO statements. For other agencies which do not access funds through budget, the amounts would be transferred to project bank accounts through which expenditure would be carried out.

[9] Vouchers, M-Book, contractors register, works register, bank statements, bank books, and bank reconciliation statements. The formats currently used by the agencies would also be followed for the project also.

(c) **Accounting at the MoWR, RD&GR.** The MoWR, RD&GR will create an accounting unit at the PMU, which will consolidate all the reports from state and central agencies and submit reports to the World Bank. An Excel-based tool or Tally software would be implemented at the central level to compile and report the accounts for the project. This will be done in the first six months of the project. The MIS platform is being developed wherein the accounting reports would be captured and online reporting could be generated at central level. This would be piloted and rolled out in the first year of operation.

Interim Unaudited Financial Reports

39. IUFRs would be the basis of disbursement. A consolidated IUFR would be submitted by the MoWR, RD&GR within 60 days from the end of each half year.

Staffing

40. FM staffing needs to be augmented at the MoWR, RD&GR and in the states to carry out the compilation and consolidation of reports. At the MoWR, RD&GR, an FM cell is being created, which would guide, support, and consolidate the project data. The FM cell would be headed by a chartered accountant, while in the states, staff on deputation or commerce graduates with good computer skills can be hired to carry out this assignment.

External Audit Arrangements

41. The project financial statements will be annually audited by the CAG for core departments and Chartered Accountancy firms for other legal entities. More than 95 percent of the agencies would be audited by the Auditor General[10] of respective states as they are the current auditors for these agencies. At the central level, the audit would be done by the office of the CAG, while the audit of state departments would be carried out by state offices of the CAG. The audit report of the central agencies that do not operate bank accounts would be provided by their respective auditors. Audit reports would be tracked IA-wise, and these audit reports should be submitted within nine months from the end of the financial year. If any entity has overdue audit reports, then its disbursements would be discontinued till the audit report is submitted to the World Bank**.**

Internal Audit Arrangements

42. Internal audit would be an integral part of the project design. Chartered accountancy firms would be hired to carry out the internal audit of the project. The firms would be selected region-wise and would be hired by the NPMU. The scope, selection process, frequency of audit, and the terms of reference are being firmed up and would be reflected in the FM Manual.

[10] In case AG expresses inability to conduct audit alternatively CA firms can be used to conduct and complete the audit as per agreed TOR.

F. Disbursements

Disbursement Arrangements

43. The GOI will use the budgetary resources to pre-finance project expenditures. The World Bank will reimburse the project upon submission of IUFRs based on actual expenditure. The MoWR, RD&GR will submit one consolidated IUFR within 60 days from the end of each half year, which will form the basis of disbursement from the World Bank. While this is the minimum requirement, the project can submit interim IUFRs to claim disbursements. There would be no designated advance for the project.

Retroactive Financing

96. The GoI is planning to finance certain contracts using retroactive financing arrangement. A separate IUFR would be submitted for claiming the retroactive expenses. Retroactive financing up to an equivalent of 20 percent of the World Bank's contribution to the project will be available for financing eligible expenditures incurred up to one year before the credit signing date.

G. Procurement

44. Procurement for the proposed project will be carried out in accordance with the World Bank's 'Guidelines: Procurement of Goods, Works, and Non-Consulting Services under IBRD Loans and IDA Credits & Grants by World Bank Borrowers' (dated January 2011, revised July 2014); 'Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits & Grants by World Bank Borrowers' (dated January 2011, revised July 2014); and the provisions stipulated in the Legal Agreement. The project would be subject to the World Bank's Anticorruption Guidelines (dated October 15, 2006, and revised January 2011).

Procurement Implementation Arrangements

45. Each of the 49 IA will be responsible for procurement and contract management for their project activities with dedicated staff at PMUs and trained staff at divisions. Based on lessons from HP-II, a list of goods and equipment that meet the technical requirements is being drawn up and will be maintained and updated regularly at the national level. The CWC is the responsible agency for creating, maintaining, and updating the list of equipment, suppliers, and manufacturers, which meet the technical requirements.

Procurement Risk Assessment

46. Under the implementation arrangements as presently finalized for the project, the Procurement Risk Assessment and Management System has been carried out on a sample of IAs and has been finalized. Considering the mix of IAs, their experience of implementing World Bank–funded projects, and the experience of implementation of HP-II, considering the role and responsibility of the NPMU and TAMC, and based on the assessment and the mitigating measures proposed, the residual procurement risk rating is rated 'Substantial'.

47. Based on the present assessment, the following risks and mitigation measures have been identified that would need to be implemented: (a) preparation of a Procurement Manual; (b) hiring of a TAMC to assist in procurement at the national level; (c) hiring of procurement support consultant at the IA level where capacity is weak; and (d) mandatorily using the empanelment list drawn up, maintained, and regularly updated by the CWC for the list of equipment and goods for carrying out procurement of hydromet and real-time data acquisition systems and forecasting systems.

Table 3.7. Risk and Mitigation Measures

Risk	Risk Factors Rating	Mitigation Measures	Residual Risk
Multiple IAs with procurement in states at district/zone level pose risk of inadequate coordination and oversight.	High	The NPMU will hire a consulting firm (TAMC) that will provide extensive procurement support to states though field offices. The NPMU will facilitate uniformity and consistency in the procurement procedures and documents of all IAs.	Substantial
		Each state will have an SPMU, with responsibility for overall coordination. It will have procurement specialists to provide guidance to the field staff on procurement matters. Many states have experience of procurement up to the field level.	
		For prior review cases, the NPMU will carry out quality check on all procurement documents to be prepared by the IAs and then forward the same with its recommendations to the World Bank for prior review.	
		NPMU will conduct concurrent review of procurements and carry out capacity-building activities.	
Low capacity in NPMU and IAs in World Bank procurement procedures	Substantial	Procurement experts in the TAMC will provide extra support at the IA level while IAs will also engage additional procurement support.	Moderate
		Three procurement training workshops with specific emphasis on verification of documentation by issuing organizations, and so on, have been conducted by the World Bank and additional trainings are planned. Refresher training workshops will be conducted by the World Bank during early stages of implementation.	
Inconsistencies in procurement systems of IAs with respect to the World Bank guidelines and Standard Bidding Document (SBDs)	Substantial	Procurement will be carried out in accordance with World Bank Guidelines.	Moderate
		IAs have been advised to use World Bank SBD and model bidding documents as agreed with the GOI task force, including conditions for national competitive bidding (NCB)	
		The Procurement Manual is at advance stage of preparation. It describes the procurement procedures for guidance of IAs. Standard documents and guidelines are also posted on project website.	
Probability of staff handling procurements being transferred	High	Transfer of trained procurement staff is a possibility. While agencies have agreed to continue, they have been advised to train large number of staff including in the field.	Substantial

Risk	Risk Factors Rating	Mitigation Measures	Residual Risk
		There will be continuous capacity-building and training programs for the staff on World Bank procurements	
Low technical expertise in instrumentation at the state level	High	Ministry has issued guidelines where it is mandatory to use the empanelment list maintained by the CWC for procurement of hydromet and real-time data acquisition systems.	Moderate
		During contract implementation, the supply and installation of hydromet equipment and the quality assurance function will be carried out by the CWPRS supported by the consultancy.	
Governance issues including misrepresentation and collusion by bidding community	Substantial	Additional trainings are planned for officers of the IAs to conduct detailed reviews and on how to identify issues related to misrepresentation/fraud and collusion and be vigilant.	Moderate
		Specific programs with an eye on fraud and corruption would be delivered and the course materials are being developed with the help of the Integrity Vice Presidency of the World Bank.	
		Numerous market sounding and vendor workshops have been conducted during the preparation phase and will be continued during implementation.	
		The use of e-procurement system has been made mandatory; subject to assessment and acceptance of the system.	
		A complaint-handling mechanism will be developed which will be easy accessible and trackable through NHP project website. In addition link to the World Bank Integrity Vice Presidency hotline would be provided on the NHP website.	
		Internal audit would be an integral part of the project design, which would include procurement review. The firms would be selected region-wise and would be hired by the NPMU. The terms of reference for the internal auditor would be reviewed by the World Bank.	

E-procurement System

48. The procurements under the project will be carried out using the e-procurement systems of the IAs. The World Bank has earlier carried out an e-procurement system assessment against the multilateral development banks requirements, and many state/IA systems have been approved as acceptable for use under World Bank–funded projects. If there are any systems being used by an IA whose e-procurement system has not been assessed, the World Bank would carry out the system assessment and provide an approval before use of the system for procurement under the project.

Procurement Plan

49. The full details of the procurements to be carried out under the project have been finalized and will be disclosed in the Procurement Plan. The Procurement Plan would list out all the

procurements to be financed by the World Bank, the different procurement methods or consultant selection methods, the need for prequalification, estimated costs, prior review requirements, and time frame as agreed between the borrower and the World Bank. The draft Procurement Plan for the first 18 months has been prepared and this will be posted on the NHP website and on the World Bank's external website.

50. The World Bank has introduced a new system, Systematic Tracking of Exchanges in Procurement (STEP). The IAs will need to use STEP to create and revise Procurement Plans under Investment Project Financing and monitor the performance and related documentation for all steps in a procurement activity, including activities that are prior reviewed by the World Bank and contracts subject to post review. The Procurement Plan will be updated using the system at least annually, or as required, to reflect the actual project implementation needs and improvements in institutional capacity.

51. The following major procurements are envisaged under the project:

(a) **Procurement of works.** The project envisages construction of a number of data center buildings at the state level and some renovation and repair works. All the building works would be of value less than US$10 million and would be procured following NCB/shopping method. The SBDs of the World Bank, as agreed with the GOI task force (as amended from time to time) for all procurement under NCB, will be used.

(b) **Procurement of goods.** The project envisages procurement of different types of equipment as well as systems such as hydromet systems, real-time data acquisition system, and so on. ,

Box 3.1. Centralized versus Decentralized Procurement Arrangements

Hydromet procurement would be one of the critical items under the project. The option of following centralized procurement was discussed. The procurement is not only related to just equipment but also integration and commissioning of multiple sensors with telemetry and datalogger, including minor civil works customized to site and combination of sensors. It means there is a need for a firm that acts as a system integrator, for which a supplier through centralized procurement would not be feasible. To ensure the accountability of the firm for equipment and installation and also O&M in the long term, the splitting of responsibilities was not found to be a viable option. During HP-I, centralized procurement was attempted and it recommended that more effective participation of state agencies in case of procurement of goods and services would facilitate efficient implementation. With decentralized procurement during HP-II, the challenges with technical evaluation of hydromet procurement were experienced.

Based on the experience of centralized and decentralized procurement during HP-I and HP-II, respectively, an empanelment list is proposed for all goods and equipment to be procured centrally and maintained and updated regularly by the CWC. This would, to a large extent, reduce the technical evaluation issue and also mitigate the risk of lack of technical expertise at the agency level.

In the second stage, the IAs would initiate procurement following the method agreed. Based on their customized need of sensors and setup, they will refer to the empanelment list in the bidding documents/request for quotations from bidders. The IAs will be required to use a simple procurement document for financial bids for hydromet system supply and installation. During contract implementation, the supply and installation of hydromet equipment and the quality assurance function will be carried out by the CWPRS. Further data validation will be done by the concerned central agencies.

The rates for the telemetry system will also be standardized through central procurement services and states will procure from the recommended provider.

(c) The project envisages that certain procurements like satellite imagery and related analysis may have to be procured from government-owned entities such as the NRSC, IMD, and SOI. Other goods, including IT equipment and software, will be procured following international competitive bidding (ICB), NCB, and shopping methods. Framework Agreements using Directorate General of Supplies and Disposals (DGS&D) rate contracts can be used to procure goods up to the NCB threshold, subject to incorporation of the right to audit and fraud and corruption clauses. The SBDs of the World Bank, as agreed with GOI task force (as amended from time to time) for all procurement under NCB, will be used. For ICB contracts, the World Bank's latest SBDs will be used.

(d) **Procurement of non-consulting services.** The Government has indicated its wish to move from the usual practice of procurement of equipment to a new mechanism of 'procurement of data' from a service provider who would be responsible for installation of the equipment and systems and would be paid for supplying the required data. This model entails the service provider to prefinance the capital cost of equipment and systems, install, operate, and maintain them, and recover the costs through supply of data to the Government over a long term, say 10 years. The financing model and the procurement documents for this innovative approach would be developed after carrying out detailed market analysis.

Review by World Bank

52. All contracts not covered under prior review by the World Bank will be subject to post review during implementation support missions and/or special post review missions, including missions by consultants hired by the World Bank. For the avoidance of doubts, the World Bank may conduct, at any time, an independent procurement review of all the contracts financed under the loan. Two missions in a year, each at an interval of six months, are envisaged for procurement supervision of the proposed project.

Table 3.8. Major Procurement Packages under the Project

S. No.	Agency	Type	Value (US$, millions)	Number	Remarks
Prior Review					
1	CWC	Empanelment of hydromet and water quality lab equipment*	58	1	Goods
2	All IAs	SCADA and hydromet (before effectiveness of empanelment)	15	15	Goods
3	All IAs	Construction/renovation of data centers/training centers	9	10	Works
4	MoWR, RD&GR	Technical and management consultant	16	1	Consulting services
5	CWC	River basin streamflow forecasting and others (including e-SWIS)	11	3	Consulting services
6	CWC	River basin water resources assessment and planning	17	10	Consulting services
7	CGWB	Groundwater modeling	2	1	Consulting services
8	SOI	High-resolution DEM survey	16	1	Non-consultancy services
	Grand Total		**144**	**42**	
Post Review					
1	All IAs	IT equipment	14	1	Goods (DGS&D)
2	All IAs	Furnishing of PMU offices and data centers	7	1	Goods
3	States	O&M of existing hydromet installed during HP-I and HP-II	6	10	Goods
4	States	O&M of existing hydromet installed during HP-I and HP-II	6	10	Goods
5	All IAs	Construction/renovation of hydromet stations	8	15	Works
6	All IAs	Construction/upgrade of water quality labs	1	50	Works
7	States	Streamflow forecasting and reservoir operation, river basin assessment, GW modeling, and so on	33	120	Consulting services
	Total		**69**	**197**	
	Grand Total		**85**	**239**	

Note: *The actual procurement and award of contracts would be carried out by the individual IAs.

Selection of Consultants

53. All the consultancies required under the project are still to be finalized and the selection/hiring of such consultancies shall follow the World Bank Guidelines. The World Bank's Standard Request for Proposal document will be used as a base for the selection of consultancy services that are to be procured under the project. Only a few large value and critical consultancies have been identified: (a) TAMC and (b) consultancies for river basin flood forecasting and river assessment. In addition, consultancies will be required for updating of software and studies. The project also envisages collaboration with multiple international institutes to support establishment of center of excellence and training centers, which would be identified based on the technical expertise required.

Record Keeping

54. Based on the procurement post reviews carried out during HP-II, there is scope for improvement of documentation and record keeping at the IA level. All records pertaining to the award of tenders—including bid notifications, registers pertaining to sale and receipt of bids, bid opening minutes, bid evaluation reports, all correspondence pertaining to bid evaluation, communications sent to/with the World Bank in the process, bid securities, and approval of invitation/evaluation of bids by the Empowered Committees—are maintained by each IA in electronic and physical files. Further, each IA maintains records relating to variation orders, monthly progress reports prepared by the project, monthly/quarterly/annual progress reports furnished by consultants (covering physical/financial/contractual issues), inspection reports of the MoWR, RD&GR/IA officers, correspondence of claims, final award on claims, and so on. Ideally, a separate file should be maintained and retained by IAs for each contract.

Disclosure of Procurement Information

55. The following documents shall be disclosed on the ministry and IA websites: (a) Procurement Plan and updates; (b) invitation for bids for goods and works for all ICB, NCB, and shopping contracts; (c) request for expression of interest for selection/hiring of consulting services; (d) contract awards of goods and works procured following ICB/NCB procedures; (e) list of contracts/purchase orders placed following shopping procedure on quarterly basis; (f) list of contracts following direct contracting on a quarterly basis; (g) monthly financial and physical progress report of all contracts; and (h) action taken report on the complaints received on a quarterly basis.

56. The following details shall be sent to the World Bank for publishing in the United Nations Development Business and World Bank external website: (a) invitation for bids for procurement of goods and works using ICB procedures; (b) contract award details of all procurement of goods and works using ICB procedures; and (c) list of contracts/purchase orders placed following direct contract procedures on a quarterly basis.

57. Further, the MoWR, RD&GR/IAs will also publish on their websites any information required under the provisions of 'suo moto' disclosure, as specified by the Right to Information Act.

Contract Management

58. Each IA should be properly and fully staffed and will be responsible for overall project/contract management. The team will be ably assisted by a multidisciplinary technical and management consultant, engaged to provide overall implementation support and monitor all works, goods, non-consultancy, and consultancy contracts. Moreover, an e-contract MIS will be developed to monitor overall project progress, critical contract management milestones, and reporting.

H. Social Development

59. The project is not expected to have any adverse social impacts and does not trigger World Bank Safeguard Policies Indigenous Peoples OP/BP 4.10 and Involuntary Resettlement OP/BP 4.12. The project interventions will contribute toward improving flow of information to farmers by collecting reliable data on water regime. The small and marginal farmers dependent on water resources will be able to take informed decisions. The hydromet system will be located on land, close to the banks of rivers, that is generally government land. However, a screening matrix and consultation action plan will be developed to ensure transparency in selection of land for installation of equipment. The project will support the information dissemination to the farmers and will set up a system for grievance management.

60. The project is not expected to have adverse social impacts. The project when implemented in scheduled tribal areas or areas covered by the Forest Rights Act 2006 will not trigger OP/BP 4.10 as forest and/or any land on which the scheduled tribes depend to meet their social, economic, and cultural needs will not be used for the project. However, they will enjoy the benefits of CBWRM program, if required to be implemented in such areas. When this is required, the CBWRM plans will be prepared using free, prior, and informed process of consultations with communities. The investment will cover modernization of existing and expansion of hydrology monitoring stations, laboratories in existing buildings, or on government-owned land, free of any encumbrances. New hydromet stations would be predominantly installed in the northeastern states while other states would largely upgrade the existing ones. Hydromet sensors for river flow measurement will be located very close to the river bed, on public land that is free from any use. For each installation in the project where land is required (even if public), a formal and transparent screening will be undertaken to determine and certify that such land is free from encroachment and private use. In very rare and exceptional cases, where government-owned sites are not available, small (approximately, 5 m^2) equipment rooms could be built on private land after leasing from landowners for a mutually agreed lease rent. The terms and conditions for lease will be clearly explained to landowners before signing of a mutually agreed lease. If required, a family member of the landowner could be appointed as a watchperson to take care of the facility. The process of agreement of landowners for such a lease will be clearly and fully documented before installation of any equipment. At the end of the first year of implementation, the process of installation of equipment on public (and the exceptional cases of private) land will be evaluated. In the unlikely event of issues noticed during this evaluation, appropriate mitigation plans will be prepared, including if required, relocation of the installed monitoring equipment.

61. A broader social benefit of the project is that it will provide access for all stakeholders to the web-based WRISs. Of particular value to the general public, especially rural people, women, and

farmers, will be real-time information on drought and flood, water regime, and crop water requirements (disseminated through information and communications technology platforms, community radio). A user satisfaction survey will be carried out at the start of the project, at midterm, and at the completion of implementation, for feedback from beneficiaries, with particular consideration of socially excluded groups and women, including women farmers. The survey will provide information for further planning and corrective actions, if required. This will be an essential part of citizen engagement and beneficiary feedback processes in the project. Additionally, the project will (a) host state-level public consultations regularly during implementation, to receive feedback and use these for improving implementation and (b) publicize the World Bank's grievance redress service.

I. Environmental Management

62. 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 (a) setting in operation a reliable and accessible hydrological knowledge base of meteorology, surface water and groundwater resources, and water quality and (b) promotion of use of hydrological models and analytical tools. All 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. The benefits include, among others, access to irrigation, drinking water, and floods management.

63. An EA for the project was carried out. The project Components B and D do not have any environmental impacts. Component A, which will set up monitoring stations, data centers, and associated facilities and infrastructure, may have minor construction-related environmental impacts. These construction-related impacts will be managed by application of National Building Codes in designing and construction of the small buildings and careful, in situ disposal of all construction wastes. The chances of overlooking water quality issues have been analyzed by the EA, and as a result, the project has mainstreamed substantial investment in augmenting water quality monitoring in the country. Component C may have impacts when plans or operation DSS are implemented, and therefore, it is important to develop these through a process that identifies all relevant environmental issues, minimizes impacts, and mitigates and manages these impacts. These issues were analyzed as part of the EA, and the project design ensures that all planning and operation DSS tools including their subsequent application will include a process of identification and incorporation of the relevant environmental issues. The project will build or augment the capacity of agencies to develop terms of reference for the preparation of basin or sub-basin plans (for water resources, flood, or drought management) and to review and supervise preparation of sub-basin plans and in the process ensure that potential environmental impacts are identified, avoided, or adequately addressed.

64. No direct or indirect impact on forests or livelihood based on natural habitats, forests, or physical cultural resources are foreseen. Any potential indirect impact will be avoided or mitigated as part of the process of preparation of the sub-basin plans (that is, during implementation of Component C). The project does not finance any chemical or synthetic pesticide. In fact, rational and balanced use of pesticide, avoidance of World Health Organization Classes 1 and 2 pesticides, and adoption of integrated pest management and non pest management are expected to be

promoted by the sub-basin-level water resources arrangement plans. The project's intended improvement in reservoir operation systems may suggest improvement of operating rules for some reservoirs (that will be selected depending on the success of Components A and B during implementation). The project will examine the need for specific examination of all associated dams and as required will (a) 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 when the borrower's dam safety review and management were not found to be adequate and effective, (b) hire services of an independent panel of experts on dam safety, and/or (c) implement the requisite inspection, remedy, or any other dam safety measure. These mechanisms are covered by the Operations Manual of the project.

65. The borrowers have prepared an EA, which mainly identifies the enhancement opportunities in the project in Components A and C (in addition to the plans for mitigating the small negative impacts that could arise from the construction of monitoring stations, data centers, and associated facilities and infrastructure). As a result, monitoring of water quality and incorporation of good environmental principles (such as providing for water quality and ecological flows) are mainstreamed in the process of preparation of basin plans and in the project. The IAs have some of the requisite capacities for undertaking water quality monitoring and preparation of basin/sub-basin plans. Capacity gaps, with respect to analyses of water quality information and undertaking special-purpose water quality studies, where relevant, have been identified, and the necessary capacity-building plans are essential components of the project. The budget for managing the environmental issues (including allocation of INR 855 million for water quality monitoring and purpose-driven environmental studies) have been mainstreamed in the project. The EA including its Executive Summary was disclosed in-country on June 16, 2016, and in the World Bank InfoShop on June 29, 2016, and can be accessed from the website of the ministry (www.mowr.nic.in) and www.indiawrm.org.

Annex 4: Implementation Support Plan

INDIA: National Hydrology Project

Strategy and Approach for Implementation Support

1. The strategy for implementation support has been developed based on the nature of the project and its risk profile. It aims to make implementation support to the client flexible and efficient and focuses mainly on implementation of the risk mitigation measures.

2. The World Bank's approach to implementation support emphasizes open and regular communication with all actors directly involved in the project, constant information exchange, and adequate flexibility to accommodate the specificities of the project.

3. The implementation support strategy is based on several mechanisms that will enable enhanced implementation support to the Government and timely and effective monitoring. These mechanisms are (a) joint review missions; (b) regular technical meetings and visits to IAs by the World Bank, between the formal joint review missions; (c) NPMU reporting based on the performance agreements; and (d) internal audit and FM reporting.

Implementation Support Plan

4. The World Bank will provide timely implementation support as well as guidance to the relevant agencies regarding technical, fiduciary, social, and environmental issues. Formal implementation support and field visits will be carried out as required and will focus on the following:

(a) **Project implementation and monitoring.** The task team leaders will be responsible for overall implementation of the project and will have regular management-level meetings with the senior management of the MoWR, RD&GR/NPMU and heads of the IAs to provide strategic directions and resolve bottelnecks for timely and effective implemntation of the project. An M&E expert will also form part of the team to develop a robust M&E framework for monitoring and tracking the progress of the project. In addition, the specialized support in hydrometeorological instrumentation, information and communications technology, and hydraulic and hydrologic modeling will be supported particularly to review large packages and ensure they meet international stanadrads.

(b) **Fiduciary requirements and inputs.** Training will be provided by the World Bank's FM specialist and the procurement specialist before credit effectiveness and during project implementation. This will allow capacity to be built among IAs in matters of FM and procurement, particularly regarding World Bank procedures. Supervision of FM arrangements will be carried out as required as part of the project supervision plan and support will be provided on time to respond to project needs. Procurement supervision will be carried out on time as required by the project.

(c) **MIS.** Considering the large number of IAs (49) and the geographical spread of the

project, support would be provided to the IAs through the MIS for procurement, disbursement, and monitoring of project progress.

(d) **Safeguards.** The World Bank will monitor compliance with safeguard policies of the World Bank as stated in the EA report and the PIP (agreed social screening criteria) during the implementation support missions and technical guidance will be provided accordingly.

5. The main focus of implementation support is summarized in table 4.1.

Table 4.1. Yearwise Plan for Implementation Support*

S. No.	Expertise	Financial Year								
		2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
	Implementation & Monitoring Support									
1	Co-task team leaders	24	24	24	24	24	24	24	24	192
2	M&E Specialist	3	3	2	4	2	2	2	6	24
3	Economist	1	1	1	3	2	1	2	4	15
4	Water Resources Specialist	12	12	12	8	8	6	4	4	66
5	Hydromet/SCADA Specialist	8	8	4	4	4	4	4	4	40
6	Groundwater Management Specialist	3	4	4	4	2	2	2	2	23
7	Capacity Building Specialist	3	3	3	3	3	2	2	4	23
8	Institutional Specialist	4	4	2	2	2	2	2	4	22
	Fiduciary & Procurement Support									
9	Procurement Specialist	12	12	12	12	8	8	8	4	76
10	FM Specialist	5	5	5	5	5	5	5	5	40
	Safeguard Support									
11	Social Specialist	2	1	1	1	1	1	1	2	10
12	Environment Specialist	2	2	2	2	2	2	2	2	16
	Total	**79**	**79**	**72**	**72**	**63**	**59**	**58**	**65**	**547**

Note: *Implementation support in staff weeks.

Annex 5: Economic and Financial Analysis

INDIA: National Hydrology Project

A. Results

1. An incremental benefit-cost analysis (BCA) was conducted for the project. The economic analysis found that the net present value (NPV) is INR 50 billion (US$834 million) at a discount rate of 12 percent and INR 68 billion (US$1,132 million) at a discount rate of 10 percent.[11] The economic internal rate of return is 34.8 percent.[12]

B. Sensitivity Analysis

2. Sensitivity analysis was conducted to analyze the robustness of the results to variations in benefits and costs. The analysis was carried out for three scenarios: (1) costs increased by 20 percent; (2) benefits reduced by 20 percent; and (3) costs increased by 20 percent and benefits reduced by 20 percent. The analysis shows that the project remains economically viable across the range of scenarios, with the least favorable (scenario 3) having an internal rate of return of 27 percent (table 5.1).

Table 5.1. Sensitivity Analysis of BCA Findings

Scenarios	NPV (12%)	NPV (10%)	IRR (%)
Baseline	5,005	6,794	34.8
Scenario (1) increasing costs by 20%	4,637	6,370	31.4
Scenario (2) decreasing benefits by 20%	3,636	5,011	30.7
Scenario (3) increasing costs by 20% and decreasing benefits by 20%	3,268	4,588	27.4
Scenario (4) increasing project duration by 2 years	5,110	6,894	37.8

Note: IRR = Internal rate of return.

3. The treatment of costs, other underlying assumptions and estimation of benefits are described below.

C. Costs and Other Assumptions

4. The full project cost of INR 21 billion is taken, which includes contributions from the GOI and state governments. This includes all setting-up and operations costs of all four project components, that is, instrumentation and data collection; data analysis and information generation; development of DSS for operations; and the development of systems to support the planning of water and other infrastructure. All project costs are assumed to be incurred by year 8; subsequently,

[11] Guidance has recently been provided on the selection of an appropriate discount rate for the economic analysis of World Bank projects. It is advised to use a 'default' discount rate of 6 percent based on a future growth rate of 3 percent, but to adjust the discount rate upwards if there are reasons to expect that future growth rates will be significantly higher, which is the case of India. If a discount rate lower than the assumed 10-12 percent were used instead, then the project would be even more economically attractive.

[12] The economic internal rate of return is the discount rate that makes net present value zero.

all the systems set up during the project are assumed to be operated and maintained by the existing government staff and costed accordingly.

5. It is assumed that 5 percent of project costs are spent in each of the first two years and 15 percent in each of the subsequent six years. Annual operation and maintenance cost for all the hardware systems are estimated at 10 percent of Component A costs. It is further assumed that the hydromet systems installed as part of Component A have a life span of 10 years, and so these are replaced in years 10 and 20. This will overestimate costs since equipment bought in year 8 of the project will not have to be replaced until year 18. The analysis assumes that these costs alone would generate the benefits included in the BCA. Sensitivity analysis was conducted in order to examine the impact of higher costs and lower benefits.

6. The additional assumptions for the economic BCA are the following:

- All benefits that are described below are assumed to occur once the NHP is fully implemented, that is, starting in year 9 (so, after the eight-year project period), even though some states are likely to realize these benefits even sooner.

- Given the long-lived nature of investments, the BCA is conducted over a 25-year period.

D. Methodology for Estimating Benefits

7. A number of studies have attempted to estimate the benefits associated with hydromet systems in the last few decades. This is a nontrivial matter due to issues of attribution, the often intangible nature of benefits, and the fact that varied users of hydrological information interpret and use the information given to them in different ways, among others. Knowledge about the value of benefits associated with hydrological information is still patchy and incomplete, making accurate evaluation very difficult. Three of the more widely accepted methods that have been used for the BCA of hydromet systems are as follows:

(a) **Benchmarking.** This simple-to-use and relatively less time-consuming method analyzes the average annual losses (as a proportion of GDP) and estimates the proportion of those damages that can be prevented to determine the benefits of hydromet systems and then adjusts these estimates according to some country-specific parameters. However, this method has various limitations. Benefits that have been assessed in the historical literature can be valued, but this is problematic as the literature may not focus on losses specific to the local situation. Moreover, the GDP may not be reliably reported. Lastly, this approach is too aggregate to evaluate specific benefits of information that may be important to hydromet targeting or location.

(b) **Sectoral.** This approach analyzes the proportion of losses that are preventable and the proportion of those preventable losses that can be avoided with the hydromet systems for different sectors. This approach focuses on locally estimated costs and benefits and hence, can be data demanding.

(c) **Conditional probabilities.** This method estimates benefits by analyzing changes in the frequency distribution of losses associated with meteorological events. However, the data requirements for this method are quite extensive, which can be both costly and time-consuming.

8. This analysis uses a modified version of the sectoral approach that combines historical data and expert opinion.

E. Benefits

9. The starting point for estimating project benefits is to consider the range of potential benefits and identify those expected benefits that can be measured and monetized with some degree of confidence. Table 5.2 provides a snapshot of the three types of expected benefits—measured, measurable but minor, and not measured. These are presented by the four key components of the NHP—modernizing monitoring systems, enhancing analytical tools, transforming knowledge access, and modernizing institutions. This break-down is for illustrative purposes only, as it should be understood that all of the components make up a whole and jointly contribute to project outcomes. For example, the benefits associated in table 5.1 with 'modernized institutions' (such as through training and capacity building) cannot be generated without modernized monitoring systems and enhanced analytical tools.

10. Of the range of potential benefits, only the 'measured' benefits are formally included in the BCA: (a) flood damages that could be avoided and (b) additional water availability for hydropower generation, irrigation, drinking water, and industrial water supplies, resulting from improved operation of reservoirs. These are described further below.

11. It should be emphasized that there are many other benefits that are not included formally in the BCA because they are difficult to measure and that these could be potentially large. For example, while the benefits generated from improved water resources operations (dam management and flood management) are included in the BCA, the likely and even larger potential benefits of improved water resources planning are not for the very simple reason that the former can be measured and monetized with a degree of confidence, while the latter cannot be measured. The measurable benefits that were included in the analysis are described below. Details on the other benefits listed in the table below are provided in a separate document and available on request.

Table 5.2. Project Benefits and Treatment in Economic Analysis

Project Component	Project Benefits	Treatment of Benefits in Economic Analysis
A. Water Resources Monitoring Systems	Reduced time and staff cost of departmental consultancies (for example, geophysical surveys)	Measurable but minor
	Reduced time and staff cost of internal studies (for example, feasibility studies and project proposals)	Measurable but minor
	Avoided cost of duplicating water management software through more efficient centralized procurement	Measurable but minor
	Avoided costs of data collection through real-time data acquisition	Not measured
B. Water Resources	Reduced flooding damages	Major and measured
	Increased hydropower generation	Major and measured
	Increased drinking water supplies	Major and measured

Project Component	Project Benefits	Treatment of Benefits in Economic Analysis
Information Systems	Increased industrial water supplies	Major and measured
	Increased water availability for agriculture	Major and measured
C. Water Resources Operations and Planning Systems	Better visualization and analysis of projects/activities for improved planning and design of water-related projects	Not measured
	Improved information for more efficient and effective planning and operation of water-related projects	Not measured
	Better understanding and awareness of public health issues	Not measured
D. Institutional Capacity Enhancement	Improved transparency and data sharing across states	Not measured
	Reduced interstate water conflicts and improved cooperation	Not measured
	Social and environmental benefits	Not measured

12. As noted above, this analysis captures two main potential benefits of the NHP, which are (a) the benefits of reduced damages from flooding and (b) the benefits of better (dynamic and modeling-based) reservoir management, that is, greater hydropower generation, enhanced canal water releases for irrigation, increased drinking water supplies, and improved water supply for industrial production. It is assumed that these benefits are unlikely to occur if the individual states acted on their own and without the help of the NHP. This is not only because water resources are shared across states—and so many concerns (such as flood management) can only be dealt with jointly—but also because high-quality and large-scale data collection and data analysis (including modeling) are necessary to generate sufficient confidence in forecasts, maps, and other information products to change the planning, design, and operations of water and other infrastructure projects. A case in point is the reservoir operation schedule for each dam that has been in place from commissioning and continues to be adhered to (as far as possible) with little analytical basis because of the fear of potential catastrophes. Another example, going beyond water infrastructure, is the information base for decisions by civil authorities to evacuate citizens from a town or area to mitigate the effects of floods.

13. The overall aim of the NHP is to create an accurate, reliable, and thus credible hydromet and DSS, that are sufficient to warrant a fundamental change in behavior to more informed decision making (based on good quality data and rigorous analysis) in the water sector. Beyond piloting or testing such systems, the NHP aims to institutionalize them in ongoing operations and planning processes at the state and central government levels and thus will have far-reaching implications on water resource management and development in India. In this regard, the scale and scope of the NHP is much greater than either HP-I or HP-II, which have been the largest GOI initiatives in this direction to date and have established the requisite strong basis on which to launch this more comprehensive program. For these reasons, the benefits discussed below are attributed to the NHP.

E.1 Reduced Damages from Flooding

14. Two key components of the hydromet systems, that is, real-time data acquisition systems and RTDSS, improve the 'organization, access, and evaluation of hydromet data and forecasting of snowmelt and runoff, as well as estimates of corresponding river flow' (World Bank 2014), which in turn could reduce flood damages. According to HP-II analysis, 72-hour rainfall forecasts

from the real-time data acquisition systems have an accuracy of 60 percent; 48-hour forecasts have an accuracy of 75 percent; and 24-hour forecasts have 90 percent. Accurate rainfall forecasts allow dam operators to undertake controlled releases, which in turn reduces the need for emergency (or panic) releases that cause flooding downstream (as it happened, for instance, in Maharashtra in 2005–06 causing two out of the three flooding events).

15. The benefits from using these forecasts are estimated by taking data on flood damages in the last 20 years and projecting them into the future. Benefits are assumed to be generated after an eight-year implementation period (starting in year 9), even though some states are likely to realize these benefits much sooner. The BBMB, for instance, has used these forecasts to alter dam operations (in the Pong and Bhakra Dams) since 2013, while Maharashtra is ready to do so within the next 5 years. It is important to note that using historical data on flood damages is likely to underestimate potential benefits for a variety of reasons, including the occurrence of 'black swan' events (low probability, high-impact events) that do not appear in historical data, future population growth, and urbanization trends, and the potentially higher intensity and frequency of extreme weather events under a changing climate. Two distinct types of river basins are considered: (a) the upper Ganga and upper Brahmaputra basins, where there are no control structures and (b) other river basins, where there are control structures.

E.1.a Upper Ganga and Brahmaputra Basins

16. Flood forecasts in these basins are assumed to be used to organize timely evacuation of humans, thus saving lives otherwise lost during (flash) flooding. The value of livestock killed; damage to infrastructure; and costs of relief, rehabilitation, and reconstruction has not been included, largely due to the paucity of adequately disaggregated data.[13] If included, these would likely increase the estimated benefits from avoided flood damage.

17. The average number of human lives lost annually due to floods in the states of Assam, Bihar, Himachal Pradesh, Uttarakhand, and Uttar Pradesh during 1996–2012 is estimated from official records to be 831. To be conservative, only a proportion of the human lives lost on average in the recent past is assumed to be saved. This accounts for the fact that not all lives lost during events such as flash floods and cloudbursts can be avoided and for attribution issues. Studies in Spain and Austria that have shown that a 12-hour lead time can result in a 60 percent reduction in flood damages. Others find that evacuation rates (fraction of people who leave hazardous areas) range from 0.32 to 0.98 and up to 1 under conditions of perceived high-range risk. Based on these findings, a conservative assumption that 50 percent of lives will be saved by a 2-day forecast that is 75 percent reliable is adopted here. The statistical value of each life lost is calculated by adjusting the latest estimate of the U.S. Environment Protection Agency of approximately US$6 million to India by assuming an income elasticity of 1.5. The estimated Value of Statistical Life for India is approximately INR 0.552 crores (US$92,000 assuming an exchange rate of INR 60 to US$1). The

[13] Estimates based on state-level data available with central agencies, which do not include district-wise information on human lives and livestock loss. While estimates of infrastructural damage are available, it is unclear how much of this damage can be attributed to a onetime flood event versus cumulative impacts that weaken infrastructure over time.

average annual benefit from improved flood forecasting in these five states is thus approximately INR 2,300 million (see table 5.3).

Table 5.3. Incremental Benefits of Lives Saved in the Upper Ganga and Brahmaputra Basins

States	Average Number of Lives Lost per Year due to Floods (1996–2012)	Proportion of Lives Assumed Saved by Better Forecasting (%)	Assumed Value of Statistical Life (INR, millions)	Average Annual Benefit from Lives Saved (INR, millions)
Assam	71	50	5.52	196.0
Bihar	302	50	5.52	833.5
Himachal Pradesh	62	50	5.52	171.1
Uttarakhand	47	50	5.52	129.7
Uttar Pradesh	349	50	5.52	963.2
TOTAL	**831**	—	—	**2,293.5**

E.1.b Other River Basins

18. Flood forecasts in basins with control structures are assumed to lead to controlled releases that can avoid damages to agriculture and property due to flooding. However, even controlled releases do not necessarily reduce flood damages to zero, as excessive rainfall alone can cause flooding. For instance, of the three rounds of flooding from the Koyna Dam during the 2005–06 floods in Maharashtra, only the last two were due to emergency releases from the dam. For this reason and the others noted earlier, only a proportion of the potential lives lost and damage to agriculture and infrastructure are assumed to be avoided because of the NHP.

Table 5.4. Incremental Benefits of Lives Saved and Infrastructure Damage Avoided (Other Basins)

States	Value of Deaths Avoided				Value of Flood Damage Avoided			Mean Annual Benefits (INR, millions)
	Mean No. of Lives Lost (1996–2012)	% Lives Saved	Value of Statistical Life (INR, millions)	Mean Annual Value of Deaths Avoided (INR, million)	Mean Annual Value of Other Damage (INR, millions)	% Damage Avoided	Mean Annual Value of Damage Avoided (INR, millions)	
Andhra Pradesh	151	50	5.52	416.8	35,960.8	5	1,798.0	2,214.8
Karnataka	100	50	5.52	276.0	18,348.9	5	917.5	1,193.4
Orissa	51	50	5.52	140.8	8,430.8	5	421.5	562.3
West Bengal	194	50	5.52	535.4	7,575.8	5	378.8	914.2
TOTAL	**496**	—	—	**1,369.0**	**70,316.3**	—	**3,515.8**	**4,884.7**

19. The average number of human lives lost each year due to floods during 1996–2012 in the states of Andhra Pradesh, Karnataka, Orissa, and West Bengal[14] is estimated from published official records to be 496. The average annual damage to agriculture and infrastructure due to floods in these four states is also obtainable from these sources. It is again assumed that only 50 percent of the lives lost can be saved (refer to Section E.1.a). With regard to the reduction in damages, the BBMB reported zero damage due to floods after 2013, when the new DSS was

[14] The benefits from flood forecasting in Punjab and Maharashtra are not considered here as they are attributed to HP-II.

installed, while at least 50 percent of damage was caused by emergency releases from the Koyna Dam in 2005–06 —which could then be prevented by the more accurate rainfall forecasts according to the Government of Maharashtra. Various studies have shown that forecast improvements can reduce average annual damages by a few percentage points to up to 35 percent. A conservative estimate of a 5 percent reduction in damages—in line with the recent analyses in the region—is adopted here. Using the Value of Statistical Life for India (referred earlier) and estimated reductions in lives lost and damage to crops, buildings, and public utilities, the annual benefit of improved flood forecasting in these states is estimated to be INR 4,880 million (table 5.3).[15]

E.2 Benefits of Better Reservoir Management

20. The RTDSS could improve reservoir operations by providing optimal dam filling and release schedules, resulting in the possibility of releasing greater quantities of water for hydropower generation, irrigation, drinking water supply, and industrial water supply. A study of Khadakvasala Dam in HP-II using 35-year average rainfall data revealed that approximately 15 million cubic meters (MCM) of water that is normally stored as a buffer before the start of the typically dryer summer period could, with improved hydromet information, actually be released during summer months (in this case, for drinking water). This represents approximately 10 percent of total dam capacity. Similar studies have not been conducted for dams in other states, but expert opinion was gathered from in-depth discussions with various dam operators in a number of states. There was general agreement that approximately 1 percent of water stored in dams as a buffer could be released with more reliable forecasts. Based on this, a conservative assumption has been adopted, that 0.5 percent of additional water would be available for release. Existing reservoirs in only half of the basins are assumed to benefit from better reservoir management by the end of the project period.[16] Note that it is also assumed that (a) this water is already stored in reservoirs, calculated as the difference between the actual water level and the minimum draw-down level of each dam, and (b) these 'additional' releases are made through the regular sluices and not as emergency releases through the spillway and hence, are available for hydropower generation, irrigation, drinking water, and industrial water supplies.

E.2.a Improved Hydropower Generation

21. It is assumed that the 'additional' water released from reservoirs due to improved dam operation from more reliable forecasts will result in greater hydropower generation to supply unmet electricity demands.[17] The benefit is estimated by valuing the hydroelectricity generated by these 'additional' water releases.

22. The additional 0.5 percent of reservoir capacity released will generate an incremental 0.5 percent of hydropower. Table 5.5 shows average hydropower generation calculated over three years (2011–14) by the states. The shadow price of hydropower is taken to be INR 3.00 per kWh,

[15] As with this analysis, very few studies have disaggregated types of damage within broader categories (for example, personal losses, business losses, agricultural lands, buildings, and other infrastructure).
[16] Calculated as half of the total average annual hydropower generated in each basin.
[17] For Koyna Dam in Maharashtra, there is a daily limit on hydropower generation of 67.5 MWh. India is home to about 350 million people who lack access to electricity. Per capita electricity consumption (kWh per capita) is only around 566, compared to world average of 2,782.

a conservative estimate that has been used in economic analyses of other Bank projects in India. Thus, the average annual incremental benefit from the increase in hydropower generation is approximately INR 2,476 million (US$41.3 million) as shown in the table below. For the BCA, increased hydropower generation is assumed to begin in year 9.

Table 5.5. Incremental Benefits of Hydropower Generation

State	Mean Annual Hydropower Generated (2012–13) (MWh) from Half the Basins	% of Additional Hydropower Assumed Generated	Additional Hydropower Generation Assumed (MWh)	Average Annual Incremental Benefit (INR, millions)
Andhra Pradesh	8,553	0.5	43.0	128.3
Chhattisgarh	434	0.5	2.0	6.5
Gujarat	8,322	0.5	41.5	124.9
Himachal Pradesh	46,683	0.5	233.5	700.3
Jharkhand	622	0.5	3.0	9.3
Karnataka	18,640	0.5	93.0	279.6
Kerala	10,083	0.5	50.5	151.3
Madhya Pradesh	12,090	0.5	60.5	181.4
Maharashtra	9,026	0.5	45.0	135.4
Odisha	8,168	0.5	41.0	122.5
Punjab	7,901	0.5	39.5	118.5
Rajasthan	1,364	0.5	7.0	20.5
Sikkim	4,231	0.5	21.0	63.5
Tamil Nadu	6,532	0.5	32.5	98.0
Uttar Pradesh	2,112	0.5	10.5	31.7
Uttarakhand	18,503	0.5	92.5	277.6
West Bengal	1,806	0.5	9.0	27.1
TOTAL	**165,070**	—	**825.0**	**2,476.0**

E.2.b Enhanced Canal Water for Irrigation

23. Most irrigator farmers practice conjunctive water use, supplementing canal water supplies by groundwater pumping. 'Additional' water releases from reservoirs could allow them to avoid pumping groundwater. While the 'additional' water releases from reservoirs may not be directly used by farmers (given that irrigation schedules may differ from canal release timings), the indirect impact of increased canal and river releases could be to fill riparian water storage structures like tanks, *diggies*, *aeries*, and *ooranis*, which would then be used to irrigate crops grown in the summer months. The benefits of additional canal water releases are thus estimated as reduced (costs of) groundwater pumping in the dry months.

24. As mentioned earlier, it is assumed that 0.5 percent of the reservoir capacity of half the basins in each state will be available as additional water releases. Reservoir capacity is taken as the live storage capacities of each state as of July 2007. It is further assumed that 80 percent of the 'additional' water will be available for agriculture, based on projected water utilization for 2025.[18]

[18] Current water use for irrigation is approximately 90 percent, but it is projected to decrease over time due to the increasing use in other sectors, including domestic and industry.

The shadow price is taken to be INR 0.60 per kl.[19] Accordingly, the average annual benefit from the additional water released from reservoirs for agriculture is estimated to be approximately INR 156 million (US$2.6 million) as shown in the table below.

Table 5.6. Incremental Benefits from Canal Water Releases for Irrigation

State	Total Reservoir Capacity (BCM) of Half the Basins	Projected Increase in Reservoir Releases (%)	Proportion of Releases Used for Irrigation (%)	Additional Water Used for Irrigation (MCM)	Average Annual Incremental Benefit (INR, millions)
Andhra Pradesh	10.0	0.5	80	40.1	24.1
Chhattisgarh	1.9	0.5	80	7.6	4.6
Gujarat	5.5	0.5	80	21.8	13.1
Himachal	3.1	0.5	80	12.5	7.5
Jharkhand	0.2	0.5	80	0.9	0.6
Karnataka	8.0	0.5	80	31.9	19.2
Kerala	1.6	0.5	80	6.2	3.7
Madhya Pradesh	13.4	0.5	80	53.7	32.3
Maharashtra	4.0	0.5	80	16.0	9.6
Orissa	5.9	0.5	80	23.5	14.1
Punjab	1.2	0.5	80	4.7	2.8
Rajasthan	1.6	0.5	80	6.6	4.0
Tamil Nadu	2.1	0.5	80	8.5	5.1
Uttar Pradesh	3.2	0.5	80	12.7	7.7
Uttarakhand	2.4	0.5	80	9.6	5.8
West Bengal	0.7	0.5	80	2.8	1.7
TOTAL	—	—	—	**259.1**	**155.9**

E.2.c Improved Drinking Water Supply

25. Additional water releases from dams as a result of shifts to improved dynamic filling and release schedules could provide more drinking water. This additional availability can address summer scarcities in rural and urban areas, which cause states to spend millions in tanker water supplies and emergency water infrastructure (for example, check dams, bore wells, and pipelines).[20] Here only the benefits from supplying additional water through tankers is considered and costs saved of expenditures on new emergency water infrastructure is not measured. Note that this method is likely to severely underestimate the value of improved water supply, which would include various avoided costs, such as the costs to women and children of walking longer distances to fetch water, health costs associated using poor-quality water, and the costs of filtration and boiling, and the cost of building emergency schemes (not planned, cost-effective) among many others.[21]

[19] According to the study on which these estimates were based, the shadow price of irrigation water in water-deficient months in Pakistani agriculture was INR 0.45 to INR 1.31 for small farms, INR 0.86 to INR 1.64 for medium farms, and INR 0.95 to INR 1.84 for large farms. Taking the number of small, medium, and large farms from the Indian agricultural census, the weighted average was calculated based on these estimates.

[20] For example, the State of Kerala spent INR 550 million for emergency water supplies in 2013, while the other southern states spend around INR 3,000–4,000 million per year.

[21] The benefits of additional drinking water include the avoided economic costs of morbidity and mortality, purchasing bottled water, and fetching water over long distances.

26. Using the same assumption that 0.5 percent of 'additional' water will be available in half the reservoirs in the state, the official statistics on the live storage capacities in July 2007, and the assumption that 8 percent of the 'additional' water will be used for drinking purposes (based on the projected water utilization pattern in 2025), additional drinking water supplies are estimated to be approximately 26 MCM per year. This additional water is valued as the cost of alternative water supplied from tankers. The price of tanker-supplied drinking water varies from INR 1,000 per 500 liters (INR 2 per liter) to INR 1 per liter in Kerala, and hence a conservative estimate of INR 0.50 per liter is used. The average annual benefits from additional drinking water are thus estimated to be INR 13 billion (US$216 million) (table 5.7).

Table 5.7. Incremental Benefits of Additional Drinking Water Supplied

State	Total Reservoir Capacity (BCM) of Half the Basins	% Increase in Capacity	Proportion Used for Drinking (%)	Additional Drinking Water (MCM)	Annual Incremental Benefit (INR, millions)
Andhra Pradesh	10.0	0.5	8	4.0	2,004.4
Chhattisgarh	1.9	0.5	8	0.8	381.3
Gujarat	5.5	0.5	8	2.2	1,090.8
Himachal	3.1	0.5	8	1.2	622.9
Jharkhand	0.2	0.5	8	0.1	47.1
Karnataka	8.0	0.5	8	3.2	1,594.6
Kerala	1.6	0.5	8	0.6	309.8
Madhya Pradesh	13.4	0.5	8	5.4	2,686.2
Maharashtra	4.0	0.5	8	1.6	799.7
Orissa	5.9	0.5	8	2.4	1,175.9
Punjab	1.2	0.5	8	0.5	234.4
Rajasthan	1.6	0.5	8	0.7	327.9
Tamil Nadu	2.1	0.5	8	0.8	422.9
Uttar Pradesh	3.2	0.5	8	1.3	635.6
Uttarakhand	2.4	0.5	8	1.0	481.1
West Bengal	0.7	0.5	8	0.3	139.4
TOTAL	—	—	—	**26.1**	**12,954.0**

E.2.d Improved Industrial Water Supply

27. The 'additional' water released from reservoirs due to better management allowed by the improved hydromet systems can also be used to augment industrial production and/or productivity, which is a national priority. Based on the projected water utilization pattern for 2025, 12 percent of the 'additional' 0.5 percent of reservoir capacity (taken as the 2007 live storage capacities) is assumed to be made available for industrial use. Given a shadow price of industrial water of INR 7.20 per kl, the average annual benefits from the incremental water supplied for industrial purposes is approximately INR 280 million (US$4.6 million) (see table 5.8).

Table 5.8. Incremental Benefits of Water Supplied for Industrial Production

State	Total Reservoir Capacity (BCM) of Half the Basins	Increase in Reservoir Capacity (%)	Proportion Available for Industrial Use (%)	Additional Water Available for Industrial Use (MCM)	Annual Incremental Benefit (INR, millions)
Andhra Pradesh	10.0	0.5	12	6.0	43.3
Chhattisgarh	1.9	0.5	12	1.1	8.3
Gujarat	5.5	0.5	12	3.3	23.6
Himachal	3.1	0.5	12	1.9	13.5
Jharkhand	0.2	0.5	12	0.1	1.0
Karnataka	8.0	0.5	12	4.8	34.5
Kerala	1.6	0.5	12	0.9	6.7
Madhya Pradesh	13.4	0.5	12	8.1	58.0
Maharashtra	4.0	0.5	12	2.4	17.3
Orissa	5.9	0.5	12	3.5	25.4
Punjab	1.2	0.5	12	0.7	5.1
Rajasthan	1.6	0.5	12	1.0	7.1
Tamil Nadu	2.1	0.5	12	1.3	9.2
Uttar Pradesh	3.2	0.5	12	1.9	13.8
Uttarakhand	2.4	0.5	12	1.4	10.4
West Bengal	0.7	0.5	12	0.4	3.0
TOTAL	—	—	—	**38.8**	**280.2**

F. Financial Analysis

28. Hydromet services are public goods, meaning that charging for them is either impossible or undesirable. For this reason a financial analysis of NHP has not been conducted. It is relevant to highlight, however, the potentially significant financial implications on government expenditures – and hence budgets – that the project could generate.

(i) **Savings in government expenditure on disaster relief and rehabilitation:** Central and state governments typically spend significant amounts of money on relief and rehabilitation efforts in the aftermath of a flood - setting up of relief camps, provision of food and medical supplies, compensation to the families of the deceased and to farmers for crops lost, etc. Timely forecasts with the help of better hydromet systems could allow both the state and central governments to save the money that would have otherwise been used for flood relief packages. These avoided expenditures could be significant. For example, states affected by floods sought central assistance in the amount of INR 280 billion in 2006, which was an 'average' flood year if not slightly higher than average. If only 5 percent of these requests were avoided, this would represent more than two-third of project costs in one year alone.

(ii) **Reduced water infrastructure construction costs:** Discussions with state-level irrigation engineers revealed that water infrastructure is typically over-designed (e.g., using a safety factor of 2.5 where a factor of 1 would suffice), implying higher costs. With better hydromet information, water infrastructure can be more optimally designed, thereby reducing investment costs. To illustrate the potential savings, it is assumed that 50 percent of the INR 4 trillion proposed for irrigation and flood control in the Twelfth Five Year Plan (2012-18)

is allocated for water infrastructure. If better information for infrastructure design results in even a 1 percent reduction in this investment outlay, the savings would amount to approximately INR 20 million (USD 333 million), or nearly 95 percent of project costs, in these five years alone.

(iii) **Savings in project design and implementation:** Better data and information for water resource planning could improve the effectiveness of large nation-wide schemes such as the newly-announced Prime Minister's Krishi Sinchayee Yojana, which is budgeted at INR 500 million over five years (2015-16 to 2019-20). If the design and implementation costs of this one scheme were reduced by just 10 percent due to activities under NHP, this would amount to savings of INR 50 million (USD 833 million) by 2020.