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Report No: {PAD1429}

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED CREDIT

IN THE AMOUNT OF US$175 MILLION

TO THE

REPUBLIC OF INDIA

FOR THE

NATIONAL HYDROLOGY PROJECT

{RVP/CD CLEARANCE DATE - SAME AS ON MOP}

Water Global Practice
SOUTH ASIA

CURRENCY EQUIVALENTS
(Exchange Rate Effective as of {Date})
Currency Unit = INR
INR 65.37 = US$1

FISCAL YEAR
April 1 – March 31
ABBREVIATIONS AND ACRONYMS

ADCP	Acoustic Doppler Current Profiler
AG	Audit General
AMC	Annual Maintenance Cost
AWP	Annual Work Plan
BBMB	Bhakra Beas Management Board
CA	Charter Accountant
CAG	The Comptroller and Auditor General
CBWRM	Community Based Water Resources Management
CGWB	Central Groundwater Board
CPMU	Central Project management unit
CPCB	Central Pollution Control Board
CPMU	Centralized Project Management Unit
CWC	Central Water Commission
CWPRS	Central Water & Power Research Station
LiDAR	Light Detection and Ranging
DC	Deputy Commissioner
DDOs	Drawing and Disbursal Officers
DEM	Digital Elevation Model
DGS&D	Directorate General of Supplies & Disposals
DSS	Decision Support System
DWLR	
EFC	Expenditure Finance Committee
EIRR	Economic Internal Rate of Return
ET	Evapotranspiration
FA	Framework Agreement
FM	Financial Management
FY	Financial Year
FYP	Five Year Plan
GD	Gauge discharge
GDP	Gross Domestic Product
e-GEMS	Ground Water Software
GFRs	General Financial Rules
GIA	Grant in Aid

GIS	Geographical Information System
GLOF	Glacial Lake Outburst Flood
GOI	Government of India
GPRS	General Packet Radio Service
GPS	Global positioning system
GSM	Global System for Mobile
GW	Ground Water
HDA	Hydrologic Design Aids
HIS	Hydrological Information System
HPII	Hydrology Project Phase 2
IA	Implementing Agency
IBRD	International Bank for Reconstruction and Development
ICB	International Completive Bidding
ICT	Information Communication Technology
IDA	International Development Agency
IMD	India Meteorological Department
INR	Indian Rupees
INSAT	Indian National Satellite
IPF	Investment Project Financing
IPRs	Independent Procurement Review
IT	Information Technology
IUFR	Interim Unaudited Financial Reports
IWRM	India Water Resource Management
MDB	Multilateral Development Banks
MIS	Management Information System
MoWR, RD&GR	Ministry of Water Resources, River Development and Ganga Rejuvenation
NCB	National Competitive Bidding
NHP	National Hydrology Project
NIH	National Institute of Hydrology
NLSC	National Level Steering Committee
NPMU	National Project Management Unit
NPV	Net Present Value
NRSC	National Remote Sensing Center
NWIC	National Water Information Center
NWRIS	National Water Resources Information System
OP/BP	Operation Policy/Business policy

PAD	Project Appraisal Document
PCS	Project Coordination Secretariat
PDO	Project development objective
PDS	Purpose Driven Studies
PFMS	Public Financial Management System
PFS	Project Financial Statements
PIP	Project Implementation Plan
PMKSY	Prime Minister Krishi Sinchai Yojna
PMU	Project Management Unit
PRAMS	Procurement Risk Assessment and Management System
RBO	River Basin Organization
RD&GR	River Development & Ganga Rejuvenation
RTDSS	Real Time Decision Support System
SBD	Standard Bidding Documents
SCADA	Supervisory Control and Data Acquisition
SMS	Short Message Service
SPMU	State Project Management Unit
eSWIS	e-Surface Water Information System
SWRIS	State Water Resources Information System
TMC	Technical and Management Consultancy
UC	Utilization Certificate
UNDB	United Nations Development Bank
USD	US Dollar
UT	Union Territory
VSAT	Very Small Aperture Terminal
WALMIs	Water And Land Management Institute
e-WQIS	Water Quality Software
WRDAS	Water Resources Data Acquisition System
WRIS	Water Resources Information System
WUAs	Water Users Association

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Practice Manager:	Jyoti Shukla
Task Team Leader:	Anju Gaur

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	
Lending Instrument Investment Project Financing	Fragile and/or Capacity Constraints [ ]		
	Financial Intermediaries [ ]		
	Series of Projects [ ]		
Project Implementation Start Date 01-Jan-2016	Project Implementation End Date 31-Apr-2024		
Expected Effectiveness Date 01-Nov-2016	Expected Closing Date 30-Apr-2024		
Joint IFC No			
Practice Manager/Manager Jyoti Shukla	Senior Global Practice Director Jennifer J. Sara	Country Director Onno Ruhl	Regional Vice President Annette Dixon
Borrower: Ministry of Finance, DEA			
Responsible Agency: Ministry of Water Resources, River Development and Ganga Rejuvenation			
Contact: Shashi Shekhar		Title: Secretary	
Telephone No.: 23715919		Email: secy-mowr@nic.in	

Project Financing Data(in USD Million)					
[ ]	Loan	[ ]	IDA Grant	[ ]	Guarantee
[X]	Credit	[ ]	Grant	[ ]	Other

Total Project Cost:	350.00	Total Bank Financing:	175.00
Financing Gap:	0.00		

Financing Source	**Amount**

BORROWER/RECIPIENT	175.00
International Development Association (IDA)	175.00
Total	350.00

Expected Disbursements (in USD Million)

Fiscal Year	0000	0001	0002	0003	0004	0005	0006	0007	0008	
Annual	2	20	33	50	60	75	60	25	25	
Cumulative	2	22	55	105	165	240	300	325	350	

Institutional Data

Practice Area (Lead)

Water

Contributing Practice Areas

Cross Cutting Topics

[X] Climate Change

[ ] Fragile, Conflict & Violence

[ ] Gender

[ ] Jobs

[ ] Public Private Partnership

Sectors / Climate Change

Sector (Maximum 5 and total % must equal 100)

Major Sector	Sector	%	Adaptation Co-benefits %	Mitigation Co-benefits %
Information and communications	General information and communications sector	40		
Agriculture, fishing, and forestry	Irrigation and drainage	20		
Public Administration, Law, and Justice	Public administration- Water, sanitation and flood protection	15		
Water, sanitation and flood protection	Flood protection	15		
Agriculture, fishing, and forestry	General agriculture, fishing and forestry sector	10		
Total		100		

☑ I certify that there is no Adaptation and Mitigation Climate Change Co-benefits information applicable to this project.

Themes		
Theme (Maximum 5 and total % must equal 100)		
Major theme	Theme	%
Environment and natural resources management	Water resource management	80
Public sector governance	e-Government	20
Total		100

Proposed Development Objective(s)

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

Components

Component Name	Cost (USD Millions)
Water Resources Data Acquisition System	147.00
Water Resources Information Systems	48.00
Water Resources Operations and Planning System	56.00
Institutional Capacity Enhancement	83.00
Contingency	16.00

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	High
7. Environment and Social	Low
8. Stakeholders	Low
9. Other	
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:	
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		**TBD**
Projects in Disputed Areas OP/BP 7.60		**X**

Legal Covenants

Name	**Recurrent**	**Due Date**	**Frequency**

Description of Covenant

Conditions

Source Of Fund	**Name**	**Type**

Description of Condition

Team Composition

Bank Staff

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

Krishnamurthy Sankaranarayanan	Financial Management Specialist	Sr Financial Management Specialist		GGO24
Jai Mansukhani	Team Member	Program Assistant		SACIN
Nagaraja Rao Harshadeep	Team Member	Lead Environment Specialist		GENDR
Pyush Dogra	Environmental Specialist	Senior Environmental Specialist		GEN06
Rafik Fatehali Hirji	Team Member	Sr Water Resources Spec.		GWA06
Samuel Thangaraj	Safeguards Specialist	Consultant		GTC06
Satya Priya LNU	Team Member	E T Consultant		GWA06
Shankar Narayanan	Safeguards Specialist	Senior Social Development Specialist		GSU06
Tapas Paul	Environmental Specialist	Senior Environmental Specialist		GEN06
William Young	Team Member	Lead Water Resource Management Specialist		GWA06

Extended Team

Name	Title	Office Phone	Location
Carter Borden	Consultant		
Chabungbam Rajagopal Singh	Consultant		
Johan Grijsen	Consultant		
Renjit Cheroor Sukumaran	Consultant/CDD		

Locations

Country	First Administrative Division	Location	Planned	Actual	Comments

Consultants (Will be disclosed in the Monthly Operational Summary)

Consultants Required?	Consultants will be required

I. STRATEGIC CONTEXT

A. Country Context

1. India is the world's second most populated country with 1.25 billion people. It is the 10th largest economy and represents around 2.5 percent of global Gross Domestic Product (GDP). Economic growth in India has steadily risen over time, resilient even to global economic crisis; by 2014-15 growth was 7.3 percent and is projected to accelerate in the years ahead.

2. India has achieved significant development outcomes including lifting over 50 million people out of poverty since 2005. India achieved the first Millennium Development Goal (MDG) of halving the proportion of people living on less than US$1.25/day[1].

3. While India has made remarkable progress and economic growth is projected to remain strong, the country continues to face daunting development challenges. More than 400 million people (one-third of the world's poor) still live on under US$1.25/day with India's poorest States some of the most highly populated. Further, an estimated 65 percent of India's population is rural and directly dependent on agriculture. Roughly 26% of India's rural population is poor and depend largely on low-productivity agriculture. Although India's ranking on the United Nation's Human Development Index has improved, it still lags behind the vast majority of nations, at 130 out of 188 countries in 2015.

4. Given the huge population food security has always been a major challenge. Massive investments in water resources infrastructure over the last 150 years helped eliminate famine and fueled broad-based development. The agricultural revolution transformed India from a country dependent on food imports into a food secure nation with annual agriculture exports exceeding USD 44 billion. This could be possible only due to expansion of irrigation, which had gradually expanded to 103 million hectares of cropland. Notwithstanding, for some years now agriculture sector performed below expectation, and improved performance in agriculture is crucial for lifting most people out of poverty. The challenge to serve irrigation to 60% less productive rainfed cropland continues. India has abundant water resources compared to many other countries, but due to large spatio-temporal variation across the country, and total storage of only 15 percent of mean annual flow, the water security and its management is a major problem. Although agriculture's contribution to GDP continues to fall, the sector employs 50% of the labor force, accounts for 90% of national water use and is critical to the socio-economic fabric of India. National food security, water allocation among states and sectors and irrigation practices and policies are key political issues dominating national water resources. Recently a flagship program (Prime Minister Irrigation Scheme) of more than USD 8 billion has been introduced to serve rainfed area in the country. The agriculture is already largest user of water in the country and 70% of India is already water constrained, further expansion warrants for a strategic approach based on water availability and uses of various sectors.

5. 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. Flood mitigation is thus of critical importance as 16 million people (~7% population) are affected annually with an estimated average annual cost to the economy of USD

[1] World Bank (October 2015), India Country Snapshot.

14 billion. Similarly drought affects one-sixth cropped area and 12% of the population. 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.

6. In response to the intricacies of managing water resources efficiently and sustainably across India, the national government and most state governments have recognized the importance of improved information about water resources as essential for efficient and sustainable water resources management in order to ensure water security across all sectors and minimize constraints on economic growth.

B. Sectoral and Institutional Context

7. Under the Indian Constitution water management is primarily a state subject. The Government of India (GOI) however, has responsibility for inter-state river planning and management issues. The central Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR, RD&GR) is responsible for formulating legislation, policies, strategies and operational guidelines, both for its own responsibilities and to guide and assist state government. The central ministry is supported by its key technical bodies – the Central Water Commission (CWC) and Central Groundwater Board (CGWB). Key policy documents include the National Water Policy, the National Hydrometeorological Data Dissemination Policy, and relevant sections of the GOI's 12^{th} Five Year Plan (FYP). GOI has also passed environmental laws that indirectly influence water use and management, including groundwater. CWC, CGWB and the Central Pollution Control Board (CPCB; under the Ministry of Environment, Forests and Climate Change) are responsible for monitoring surface and ground waters (quality and quantity) at the macro and inter-state levels.

8. State agencies prepare and implement development projects for flood management, irrigation and drainage, water supply and hydrometeorological data collection. Although states are responsible to operate reservoirs, the streamflow forecasting during floods is provided by CWC based on their request. The agencies undertaking water monitoring include irrigation/water resources, groundwater, drinking and water supply departments, and in some cases river basin organizations. There is diverse and not always consistent state legislation for irrigation, and water resources management, and roles and responsibilities are often fragmented across multiple state agencies leading to coordination and data sharing challenges.

9. Renewed political commitments, at all levels, for improved flood management provide a strong an undisputed basis for better water information systems. There is also growing recognition by states of the need to model and run inclusive river basin operations across states in multi-state river basins, although reticence for water allocations and formal water rights has tended to slow the establishment of a functional and transparent water information system. Recognizing a national water information system is critical for effective water resources management, a comprehensive National Hydrometeorological Data Dissemination Policy (2013) was introduced to facilitate the data exchange amongst national and state agencies. The policy entitles web-registered users to freely download all unclassified hydrometeorological data. The policy is highly significant in the context of the new GOI "Digital India" initiative that seeks to e-connect government departments and citizens for effective governance.

10. Both National and state governments are committed to building a comprehensive national water resources information system that supports integrated river basin planning and management. An ambitious program of water resources data collection and management was supported by the World Bank-funded Hydrology Projects (Phases I 1995-2003 and II 2006-2014) predominantly in southern India. Both the phased of Hydrology Project helped the southern (peninsular) states, Himachal Pradesh and Punjab build a comprehensive Water Resources Information System (WRIS) and standardize databases and decisions support systems (DSS) for river basin operation, planning and management. WRIS is an integrated system providing comprehensive, reliable and timely hydrometeorological data. The investment built scientific hydrometeorological observation networks for surface and groundwater (quantity and quality), established data processing and storage facilities, set up reliable data communications, and trained staff for operations and user support. These projects introduced a culture of hydrometeorological monitoring. The second phase project enabled a paradigm shift in hydro-informatics and operational water management from manual to automatic real-time monitoring and data transmission, from simplistic operational water resources infrastructure management to sophisticated and effective operation management of key reservoirs, and from data secrecy to greater transparency. The projects established water data centers and modernization of design, operation and planning units across water resources agencies. State departments began to understand the importance of a river basin approach. WRIS together with modern software tools supported improved structural designs, faster project clearances and alternate cost-effective investments. The real-time monitoring and DSS for reservoir operations and for water management in a few locations reduced flood damages and improved water resources management.

11. HP-II was instrumental in promoting real-time hydro-met systems – introduced mid-way through the project. Given the novelty of the technology there was no experience within implementing agencies and hence adoption was limited to selected locations. The real-time monitoring and decision support systems for reservoir operation and for water management proved to be very effective in reducing flood damages and improving water resources management. Based on this success, demand for these novel technologies has grown from both former project agencies as well new agencies. Additionally, and critically, monitoring systems need to be extended to include irrigation canals which account for 85% of total water use in India.

C. Higher Level Objectives

12. The project is closely aligned with GOI water sector priorities set out in the 12th Five Year Plan (FYP) (2012-2017); which calls for a paradigm shift in the management of water resources including improvement of systems for water data collection, management and open access. The FYP also called for a renewed focus on non-structural flood management and highlighted the need for national aquifer mapping. A FYP working group, recognizing Hydrology Project efforts, and recognizing the value of accurate water resources information recommended an integrated national WRIS. The GOI is now committing to continue the project with programmatic approach and introduce as centrally sponsored scheme. The continued partnership between GOI and the World Bank through last two phases of project has clearly demonstrated Institutional strengthening is complex and time consuming as it involves major cultural change in the construction centric Institutional development of data/information and use of River basin planning. Therefore, the project is being proposed with eight years duration.

13. The Bank's Country Partnership Strategy for India (FY 2013-2017) is aligned with the GOI 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, especially in agriculture. The proposed project will help India monitor its valuable water resources, and better manage these across sectors for inclusive growth. It will build state and national capacities for irrigation management, and will increase the productivity of rain-fed agriculture through increased water use efficiency. The project targets low income and special category states and will improve urban livelihood by enabling more reliable and better quality water supplies based on improved reservoir operations and better water quality monitoring to guide pollution control. The project will reduce flood damages through improved flood forecasting and flood operations, and will build climate resilience in water resources management systems, including through improved conjunctive use of surface and groundwater.

II. PROJECT DEVELOPMENT OBJECTIVES

A. Project Development Objective

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

B. Project Beneficiaries

15. The project has three groups of direct beneficiaries: (i) central and state agencies responsible for surface and/or groundwater planning and management, including river basin organizations; (ii) central agencies responsible for meteorology, survey and remote sensing which provide support to water resources management and (iii) rural and urban water users and those affected by floods and droughts, especially poor, small and marginal farmers. Indirect beneficiaries include stakeholders across the energy, environment and agriculture ministries; research and educational institutions; students and researchers, NGOs, civil society organizations and the private sector.

C. PDO Level Results Indicators

16. Key result indicators are:

(i) Number of direct project beneficiaries (including percent female)
(ii) Number of operational hydromet stations integrated with centralized database
(iii) Number of water information products and/or services available to stakeholders
(iv) Percent of implementing agencies achieving benchmark performance levels.

III. PROJECT DESCRIPTION

A. Project Area

17. Based on the successes of previous phases of project, the GOI wishes to expand these efforts to cover the entire country including the states of the Indus, Ganga and Brahmaputra basins[2]. National Hydrology Project (NHP) will further improve and expand monitoring systems for water availability and water use. It will emphasize real-time monitoring for operations, flow forecasting, water accounting for water resource planning and operations on a river basin basis and strengthening of community-based groundwater management. NHP will contribute to the GoI Digital India initiative by integrating across state and central agencies.

18. The project is national in nature and will cover all the states and territories of India. All states and Union Territories will participate given their constitutional mandate for water resources management. Central agencies will also participate given their role in providing technical expertise and leadership in water information and water resources assessments, and their role in the coordination of water management issues between states within a basin and their critical role in leading the adoption of a river basin approach to water resources management.

B. Project Scope

19. The project builds upon the prior HP-I and HP-II, which were focused in the peninsular states. These established improved infrastructure for water measurement and a standardized database of water resources information. They developed tools, protocols and software to validate data quality and to manage data storage and dissemination. Tools and DSS were also introduced that enabled use of data/information in water resources planning and in the operation of water resources management infrastructure in selected river basins. The proposed project will further strengthen evidence-based decisions in water resources planning and operational management across India using the latest technology and tools.

C. Project phasing

20. The project will be implemented as centrally sponsored that will ensure sustainability and continuity of program. Differences between those agencies that have participated in prior Hydrology Projects and new agencies will be managed through balancing the ambition of each agency's work plan, and through support arrangements for project implementation. Two mid-term reviews are planned to allow for adjustment of agency work plans and to allow project re-focusing.

D. Project Components

21. Evidence-based water resources decisions require not only improved water information but also better technical capacity and policy and planning capacity (Figure 1). Improved water information products (including water resources assessments, water accounts and audits, scenario

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[2] The project will cover state level water resources departments and central agencies including Central Water Commission (CWC), Central Ground Water Board (CGWB), National Institute of Hydrology (NIH), Indian Meteorological Department (IMD), Central Pollution Control Board (CPCB), Survey of India (SOI), National Remote Sensing Centre (NRSC), Central Water and Power Research Station (CWPRS), and Bhakra Beas Management Board (BBMB).

analyses and option assessments, forecasts and early warnings) require improved water data and improved tools (analytical and decisions support systems) to transform data into information. The project thus spans the value chain from water resources data to decision making capacity in water resources development and management through informed planning and operation (Figure 1). Beyond the project, this is expected to lead to improved water resources decisions generating greater economic, social and environmental benefits.

22. The project will have four components: (A) Water Resources Data Acquisition, (B) Water Resources Information Systems, (C) Water Resources Operations and Planning systems; and (D) Institutional Capacity Enhancement. These components (and their sub-components) map across the conceptual framework, with Component C spanning the application of systems/tools to generate water information products, and Component D encompassing strengthening of both technical and planning/policy capacity (Figure 1).

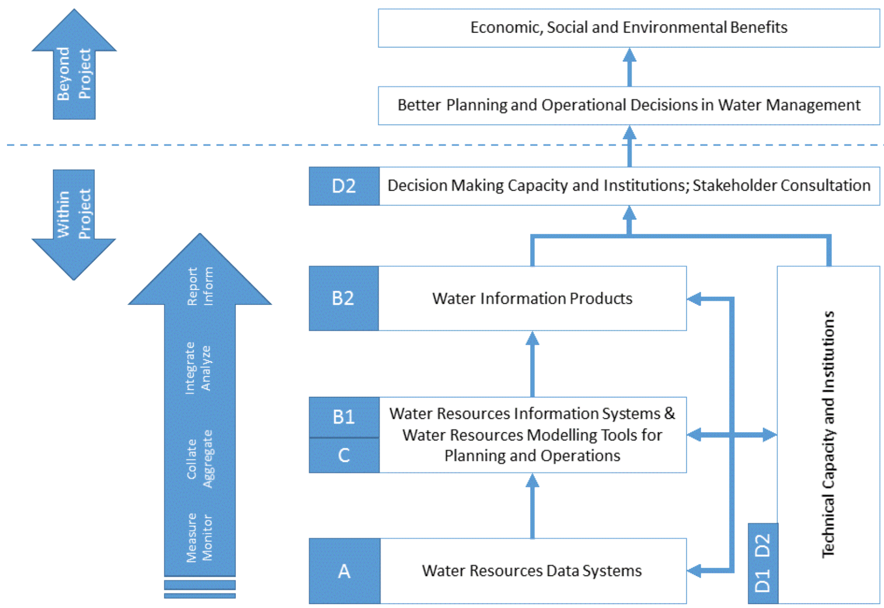

Figure 1: Project conceptual design showing components/sub-components.

Component A: Water Resources Data Systems (USD 147M)

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

(i) **Establishment of water resources data acquisition network:** data acquisition networks will be upgraded or established to measure weather variables, water quantity (inflow, outflows, use) and quality in rivers, reservoir, canals and aquifers. Supervisory Control and Data Acquisition (SCADA) systems will be installed on reservoirs and canals to improve the reliability and efficiency of operational water management. Physical measurements will made to determine site specific characteristics including river cross-sections, discharge, morphology, sedimentation and aquifer characteristics.

(ii) **Establishment of water data centers:** state and national water data centers will be upgraded or established for automated data collection, collation and processing. They will provide centralized hubs for operational control systems, and laboratories for water quality analysis. The project will support modernized infrastructures and establishment of hydrological instrumentation, and local and distributed (cloud) storage data storage.

24. Component A will support civil works for infrastructure and for establishment of hydromet sites; procurement of software/servers; and goods and services for hydromet, IT equipment and water quality equipment. A centralized framework rate contract will be used for hydromet systems, telemetry services and integrators to facilitate procurement by all agencies.

Component B: Water Resources Information Systems (USD 48M)

25. Component B aims to standardize, integrate and improve the accessibility of data, information and products through online products and web-portals for public and government-to-government. In particular, the objective is to improve the communication and exchange state and central governments and to facilitate real-time operation and decision making at river basin scale. Major activities will include:

(i) **Web-based water resources information system*:*** a web-based India-WRIS has already been developed by CWC. It will be further strengthened and populated to serve additional users. It will seek to integrate with state data and standardize river basin information for basin planning and operation as well as supporting national assessments to guide policy formulation. The sub-national level WRIS will be introduced at state and river basin levels. The data entry, acquisition and validation will be conducted with the help of web-based standardized database management system (data entry, validation and storage) developed for surface water (e-SWIS), groundwater (e-GEMS) and water quality (e-WQIS) to minimize operation and maintenance burden on states. These systems already developed during Hydrology Project Phase II, will be further improved and extended nationally to standardize collation of national and river basin databases.

(ii) **Water resources information products:** given a lack of metering of water use, remote sensing based techniques will be used to estimate water use. The project will support the development of spatial information including topographic survey, use of earth observation data for determination/prediction of evapotranspiration, precipitation and river morphology. Various products/services will be developed/introduced including weather forecasts, evapotranspiration estimates and water availability reports and outlooks for rivers and reservoirs and will be shared with all stakeholder including line departments, researchers and public. The portal will be made interactive such as river basin explorer and facilitate the integration with the applications of users through web management services. This sub-component will also support the dissemination of products developed in Component C. The knowledge portals will provide easy access to documents and online mapping, facilitate training, support social-media networking, and help visualize complex information. Support will be provided for secure within-government portals that internally share operational water resources information at national and state level.

Component C: Water Resources Operation and Planning Systems (USD 56M)

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

(i) **River basin modelling** for river basin water resources assessment, water accounting, basin systems simulation, optimization and multi-criteria models for system analysis.

(ii) **Streamflow forecasting and reservoir operation systems** to manage floods and improve lead time by integrating with climate forecasts. Forecasting tools will include weather forecasts (from seasonal to now-casting), short and medium-term streamflow forecasts, and maps of forecast flood inundation. Based on streamflow forecasts CWC and state agencies will operationalize real-time reservoir operation systems.

(iii) **Irrigation design and operation** will support modernization of design cell of irrigation departments and modernize operation of releases from reservoirs and canals based on actual crop demand monitored using remote sensing and supported by water use monitoring. Support will be provided to strengthen Water and Land Management Institutes to benchmark irrigation systems and to promote and facilitate community participation in water management. Conjunctive water management will also be introduced.

(iv) **Purpose-driven studies** are expected to cover a wide range of water management issues: surface water and groundwater, water quality, conjunctive use, and sedimentation. These studies will be coordinated by NIH and international publications will be encouraged.

Component D: Institutional Capacity Enhancement (USD 83M)

27. Component D aims to build the capability and capacity for technical and planning/policy aspects of water resources management. Increased professional capacity and stronger institutions are vital to improving decision making in water resources planning and management. The component will support:

(i) **Water resources knowledge centers**: the development of existing centers of relevant expertise and the development of new centers will focus on development of expertise. These are expected to include (i) a National Water Resources Knowledge Centre, (ii) sub-national centers and (iii) special centers (flood management, groundwater modelling). These will be supported through construction of buildings (where needed) and resourcing appropriate facilities and high caliber staff.

(ii) **Professional development**: training support will provided through a wide variety of means including classroom teaching, online courses and exchange programs. Collaboration with national and international institutes will be important in order to rapidly build the national capacity for modern water management.

(iii) **Project management:** project implementation support will be provided through consultancies for technical and administrative work, management information systems and financial reporting systems, to ensure good coordination and effective implementation.

28. Component D will support effective management and facilitation of all activities and will provide national and sub-national support for technical assistance, activity management, procurement, financial management, safeguards, training, communication, monitoring, learning, evaluation, and adaptive management. The component will support (i) a National project management unit, (ii) central and state project management units, (iii) technical quality control for hydromet equipment, (iv) monitoring and learning (M&L), and (v) governance and accountability.

E. Project Financing

29. The lending instrument will be Investment Project Financing; Table 1 shows project costs and financing by components. GoI would continue the project with programmatic approach. Considering that Intuitional strengthening is complex and time consuming as it involves major cultural change in the construction centric Institutional development of data/information and use of River basin planning, the project is being proposed with eight years duration.

Component	**Project Cost**	**Financing Share**	
		GOI	**World Bank**
A: Water Resources Data Acquisition System	147	73	73
B: Water Resources Information Systems	48	24	24
C: Water Resources Operations and Planning System	56	28	28
D: Institutional Capacity Enhancement	83	41	41
Contingency	16	8	8
Totals	**350**	**175**	**175**

Table 1: Project Cost and Contribution (in USD M)

F. Lessons Learned and Reflected in the Project Design

30. In addition to the lessons from earlier Hydrology Projects, the proposed project drew on international and regional experience. The main lessons incorporated in the project design are:

(i) **River basin approach:** riparian states in large river basins need to coordinate river basin planning, in particular, to manage floods and coordinate reservoir operation. The project is strongly adopting an integrated river basin approach for water resources management – technically and institutionally.

(ii) **Standardized and transparent data:** reliable data is critical for building confidence for data sharing. 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 operation and maintenance.

(iii) **Software and storages:** to support large numbers of software users and wide development and update of river basin tools and DSS, the project will advocate for open access software with no license fees. Cloud-based computing will also facilitate large numbers of users.

(iv) **Centre to facilitate (not control), supporting and empowering states:** the project is designed for central support to states while empowering them to make their own decisions including on procurement for hydromet, telemetry, water resources information systems, and flood and water resources models.

(v) **Remote sensing for ungauged basins:** in data-scarce regions remote sensing data will be used to support basin information/assessments.

(vi) **Flexible design:** the project design recognizes that state requirements and capacities will differ. Periodic reviews will guide reallocation of resources to support changing needs.

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

31. The National Hydrology Project (NHP) will be a centrally funded project and implemented by MoWR, RD&GR. The implementation structure has been guided by experience from HP-II. The project will have a three-tier structure for policy, management and coordination with implementation responsibilities distributed across central and state agencies. MoWR, RD&GR will be the lead implementing agency while individual implementing agencies will be responsible for their own activities and accountable for agreed deliverables.

32. A National Steering Committee (NSC) will be the project governing body with planning, advisory and coordination roles. The NSC will be supported by a National Project Management Unit (NPMU), staffed by MoWR, RD&GR and supported by a technical and management consultant team. The NPMU will be responsible for program management, monitoring and reporting, development and maintenance of a Management Information System (MIS), financial management, procurement management, change management and communication and outreach activities. National coordinating agencies have been identified for each project components; they will establish technical committees to guide implementation (Table 2).

Component	Main Function	Responsible Institution
A1	Design of hydromet and procurement	CWC, CGWB, CPCB
A2	HIF for Testing of Hydromet	CWPRS
B1	Standard database management systems	CWC, CGWB, CWPRS
B2	NWRIS standards and protocols	NWIC, CWC
B2	Data sharing protocols and monitoring	NPMU
C1,2	Flood forecasting and river basin assessment models	CWC
C1,2	River basin modeling training and expert support	NIH
C3	Scope of PDS and technical support	NIH
D1	Collaborations with International organizations	NPMU
D2	National and international trainings	NIH
D3	Overall project management, M&E and FM	NPMU

Table 2: Component-wise coordination

33. State implementing agencies will be the water resources (irrigation) departments and/or groundwater department. Some states have joint surface and ground departments. A State Steering Committee chaired by the Principle Secretary in charge of water resources will coordinate across departments. The detailed composition, mandate, roles and responsibilities of the national and state levels implementation arrangement are described in Annexure 3.

B. Results Monitoring and Evaluation

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

to track progress and performance of implementing agencies will be central to the project M&E framework. Introducing applications for mobile devices will bring all agencies into a participatory monitoring process. In addition to regular national and sub-national learning forums, the project will facilitate frequent webinars and virtual learning and knowledge sharing events.

35. The key indicators for measuring project progress and success are given in Annexure 1. Progress monitoring will cover each implementing agency, include frequent data audits and supportive supervision. The project will use innovative monitoring approaches including thematic studies, performance assessments, mapping and audits. Monitoring would use HP-II achievements as a baseline and conduct evaluations at mid-term and project closure. The mid-term evaluation would guide performance-based budget allocations to the implementing agencies.

C. Sustainability

36. Through past phases of investment in hydrometeorological data systems, the World Bank and MoWR, RD&GR have established a long-term programmatic approach that supports the central ministry's mandate to maintain a central national database, issue flood forecasts and provide regular water resource assessments. The proposed project will establish modern, innovative systems to ensure the continuity and continual improvement of these central government functions. To ensure sustainability, GOI plans to establish a National Water Information Center that will continue to support data information systems developed through the project.

V. KEY RISKS

A. Overall Risk Rating and Explanation of Key Risks

Risk Category	**Rating**
Political and governance	Low
Macroeconomic	Low
Sector strategies and policies	Substantial
Technical design of project	Substantial
Institutional capacity for implementation and sustainability	Substantial
Fiduciary	High
Environment and Social	Low
Stakeholders	Low
Overall	**Substantial**

Table 3: Summary of Key Risks

37. The overall risk rating for the proposed project is 'substantial', based on the assessments provided in the SORT matrix. The team is working with the project to address key risk areas with a view to downgrade the overall risk by the time of negotiation.

38. The major risks are: (i) a large number of implementing agencies to manage; (ii) sufficient procurement may not be in place prior to negotiation; (iii) fund transfers from central to states may be slow and sometimes budget may not be available; (vi) data access restrictions and potential unwillingness of some states to share data may compromise river basin planning; and (vii) vendors for monitoring equipment and expert consultancies may not match project requirements.

39. Risk mitigation measures include:

(i) Robust NPMU supported by international technical and management consultancy with intensive support to states and professional procurement services for weaker states. States will also be allowed to engage technical support directly. The center will coordinate and support large scale procurements such as hydromet and IT equipment using framework-based procurement. The task team is working with the NPMU to develop seamless fund flow arrangements based on the experience of other centralized projects.

(ii) The multiple-agency and limited institutional capacity risks will be managed by flexible planning and procurement, full technical support, and adjustable annual work programs determined by annual performance criteria.

(iii) The project will ensure readiness in terms of key government clearances, institutional setup and procurement of key consultancies prior to negotiation. Considering the project challenges for new agencies, the project duration has been proposed as eight years.

(iv) MoWR, RD&GR plans to transform the current WRIS into a National Water Information Center to support all IAs. To further incentivize the states, the ministry will fund states via grants. In case of major river basins, the centralized data at macro level is already available.

(v) National and international vendors are being made aware of project requirements through workshops and the project website. Similarly, for modeling skills in water resources, local research and academic institutes are being sensitized to introduce appropriate programs. It is planned to strengthen research institutes including relevant universities.

VI. APPRAISAL SUMMARY

A. Economic and Financial Analysis

40. The proposed project is focused on collecting hydrological data, generating information and making it available to support management, design and operation of water resources. The monetary value of hydrological data lies in the increased efficiency of the design or operation of water resources projects that can be achieved with improved data. The major benefits include (Table 4): (i) savings in cost and time through improved planning, design and implementation of water related investments, (ii) avoided flood damages, (iii) increased water availability with improved operation of reservoirs, (iv) increased transparency, (v) reduced inter-state conflicts and (vi) avoided costs of data collection. The Economic and Financial Analysis (EFA) has focused on estimating the value of avoided flood damages and additional water availability for hydro-power generation, irrigation, drinking water and industrial water supplies (resulting from improved operation of reservoirs).

41. Using an incremental benefit-cost methodology EFA examines the benefits and costs of project investments in order to assess the economic viability of the project. The EFA uses a modified version of the sectoral approach that combines historical data and expert opinion to estimate economic benefits. Given the programmatic nature of investments, the analysis is conducted over a 25-year time period, with benefits assumed to be generated after project completion i.e. from the ninth year onwards. All project costs are assumed to be incurred by the eighth year. Subsequently, systems set up during the project are assumed to be operated and maintained by existing government staff and costed accordingly. 12 percent and 10 percent discount rates are used. The analysis estimates the Economic Internal Rate of Return (EIRR) of the investment at 34.8 percent. The Net Present Value is INR 50 billion (USD 834 million) at a discount rate of 12 percent and

INR 68 billion (USD 1,132 million) at a discount rate of 10 percent. Further, sensitivity analysis demonstrates that if there are cost over-runs, 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 EIRR to 27 percent. The detailed analysis is in Annexure 5.

Project Component	Project Benefits	Treatment in Economic Analysis
A. Water Resources Data Systems	Reduced time and staff cost of departmental consultancies (e.g., geophysical surveys)	Measurable but minor
	Reduced time and staff cost of internal studies (e.g., feasibility studies, project proposals, etc.)	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	Major - not measured
B. Water Resources Information Systems	Better visualization and analysis of projects/activities for improved planning and design of water-related projects	Major - not measured
	Improved information for more efficient planning and effective operation of water-related projects	Major - not measured
	Better understanding and awareness of public health issues	Major - not measured
	Time saved in preparation of DPR and hence investment saving	Major - not measured
C. Water Resources Operations and Planning	Reduced flooding damages	Major – measured
	Increased hydropower generation	Major – measured
	Increased drinking water supplies	Major – measured
	Increased industrial water supplies	Major- measured
	Reduced costs of groundwater pumping for irrigation	Major – not measured
D. Institutional Capacity Enhancement	Improved transparency and data sharing across states	Major – not measured
	Reduced inter-state water conflicts and improved cooperation	Major- not measured
	Social and environmental benefits	Major –not measured

Table 4: Summary of project benefits

42. **Financial Analysis:** Hydromet services are usually public good services, meaning that charging for them would be undesirable. For this reason a financial analysis is not conducted. However, there are potentially significant financial implications on government expenditures – and hence budgets – that the project could generate. These include:

(i) **Savings in government expenditure on disaster relief and rehabilitation:** Avoided expenditure on disaster relief and rehabilitation could be significant. States affected by floods sought INR 280 billion in central assistance in 2006 (an 'average' flood year). If 5 percent of this cost could be avoided, this would justify, in a single year, over two third-quarters of project investment.

(ii) **Reduced water infrastructure construction costs:** With improved data water infrastructure can be more optimally designed, reducing investment costs and damages. To illustrate potential savings, assume 50 percent of the INR 4 trillion proposed for irrigation and flood control in the 12^{th} FYP is allocated for water infrastructure; if better information for infrastructure design could reduce this outlay by just 1 percent the savings would represent INR 20 billion or nearly 95 percent of project costs.

(iii) **Savings in project design and implementation:** Better data for water resource planning could improve the effectiveness of large nation-wide schemes such as the newly-announced national Krishi Sinchayee Yojana scheme with an INR 500 billion budget over five years (FY15-19). If design and implementation costs of this one scheme were reduced by 10 percent as a result of better data, this would represent a saving of INR 50 billion.

B. Technical

43. MoWR, RD&GR is fully committed to NHP as evidenced by provision of grants to the states and the articulated ambition of establishing a National Water Information Center. The fund allocation will be flexible and will be reallocated with respect to the performance of each agency. The ministry plans provide centralized database management systems, tools and software to reduce the procurement and maintenance burden on the states.

44. Of 37 state/UT implementing agencies, 31 already have hydrological monitoring divisions in place. The six north-eastern states (except Nagaland) are yet to establish hydrology divisions. The 20 HP-II IAs have institutional arrangements established but can improve these and streamline implementation, particularly for irrigation/reservoir management. Amongst the 20 new agencies, 9 are familiar with World Bank procurement while 11 (primarily north-eastern) will require familiarization. The north-eastern states have demonstrated their dedication to the project, nominating dedicated teams and have actively participating in project implementation training.

45. Using World Bank technical assistance, learning and sharing workshops have been organized to familiarize implementing agencies with global best practices and innovative tools, in particular on hydromet, groundwater-surface interactions and sub-surface geophysics, hydrological modeling and procurement. Since September 2014, ten training events have been organized for 550 participants. Details on training events are on the project website and in Annexure 3.

C. Financial Management

46. The financial management arrangements of the project provide reasonable assurance on use of project funds. These arrangements use the existing process and procedures of MoWR, RD&GR. The Project cost is USD 350 million with USD 175 million (50 percent) as Bank financing. A dedicated budget line under 'external aided project financing needs to be created at central and state levels. The Project fund requirement project will be budgeted each year on the basis of an Annual Work Plan (AWP). All payments will be centralized and will be made through the treasury mechanism. Accounting and reporting to the Bank in an agreed format (interim financial report – IUFR) will be based on PAO's monthly accounts. Project activities will be subject to external audit by the Comptroller and Auditor General (C&AG) as well as by the internal audit wing of the ministry. A Charted Accountancy firm will be used for the internal audit of the Project.

47. The Project will be 100 percent centrally sponsored. Fund flow from the center to states will be as Grants in Aid (GIA). While states and state implementing departments will use state financial management systems, central agencies will use their own financial management systems.

48. GOI and the states will create separate budget heads for the Project in their respective budgets. Project fund flow will be through established GOI and state systems. Accounting at central and state levels will be done on a cash basis, using government accounting systems; expenditure will

be recorded against the allocated budget at the time of payment. Accounting rules will be consistent with respective General Financial Rules (GFRs) as applicable to all transactions of central and state governments. The MIS system developed and used in Hydrology Project II for capturing component-wise expenditure may be customized for the financial reporting needs of the Project.

49. Retroactive financing: Up to an equivalent of 20 percent of the Bank's contribution to the Project will be available for financing eligible expenditures incurred for one year before the credit signing date.

D. Procurement

50. Project procurement will be conducted in accordance with the World Bank *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) [Procurement Guidelines], *Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits & Grants by World Bank Borrowers* (January 2011, revised July 2014) [Consultant Guidelines], and the provisions stipulated in the Legal Agreements. The Project will be subject to the Bank's *Anti-Corruption Guidelines* (October 15, 2006, revised January 2011). Project procurements will be conducted using e-procurement systems for eligible IAs (See Annexure 3 for details).

51. Of the 47 IAs, 36 agencies are familiar with Bank procurement and consultancy guidelines. It is envisaged that each implementing agency will be responsible for procurement and contract management for their Project activities. Based on Hydrology Project II lessons, a Framework Agreement (FA) is proposed. This will facilitate single-stage and two-stage procurement of hydromet and IT equipment or similar goods. The CPMU and/or central agencies will be responsible for initiating the first stage of the FA and determining acceptable manufacturers, suppliers and equipment.

52. Procurement arrangements will be finalized during Project preparation and appraisal taking into account procurement types, IA capacities etc.

E. Social – Including Safeguards

53. NHP will not trigger the Bank's Operational Policy/Bank Procedures (OP/BP) on Indigenous Peoples or Involuntary Resettlement, as the Project will not support major civil works requiring any land under any tenure systems (private *Patta* (titled) land and/or government lands under any tenure systems). Expansion of hydrology monitoring stations and laboratories will be in existing buildings or on state government owned land, free of any encumbrances. Hydromet sensors will be very close to rivers, on public land that are free from any use and this will not cause any adverse impact. Very small (10 m^2) equipment rooms, where appropriate government owned sites are not available, will be built on private land that will be leased from the land owner for a mutually agreed sum. If required, a family member may be appointed as a watchperson to take care of the facility.

54. No adverse impacts are expected on Scheduled Tribes in scheduled areas, as covered by the Scheduled Tribes and Other Forest Dwellers (Recognition of Forest Rights) Act (2006) with Tribal

Sub-Plans and other such Plans for tribal development, because the Project will not require any forest land or any land on which Scheduled Tribes depend for social, economic and cultural needs.
55. The project will support Community Based Water Management (CBWM) through various existing and new community-based organizations and Non-Government Organizations (NGOs). Good community-level water management practices will be identified and replicated, including for community-based hydrological monitoring. CBWM will help increase agriculture production, strengthen livelihood systems and reduce human and economic losses associated with floods and droughts. All state IAs will have a CBWM component in their Project Implementation Plan (PIP) as a main budget line with sub-budget lines for organization, motivation and operationalization of community based organizations (CBOs) and NGOs.

F. Environment – Including Safeguards

56. 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.

57. Component A, which will set up monitoring stations and associated facilities and infrastructure that may have small footprints, will have very minor environmental impacts. It is envisaged that all agencies, including central agencies working on surface and sub-surface water quality data, will bring data to a centralized platform and will share data with stakeholders.

58. Component C may have impacts when recommendations are implemented. Therefore, it would important to consider all relevant environment related implication during the planning process, such as during preparation of Terms of Reference (TOR) and ensure that scenarios consider environmental impacts. This will be taken care of by mainstreaming environmental management issues in ToR for basin or sub-basin level plans for water resources management or flood management or drought management (referred to in the Project operations manual). No direct or indirect impact on natural habitats is expected. The project will build/augment the capacity of agencies to review and supervise preparation sub-basin plans, and in the process ensure that potential environmental and social impacts are identified, avoided or adequately addressed.

59. A Project assessment and monitoring framework for water quality will be maintained. When agencies prepare river basin management plans, the assessment will be undertaken on critical environmental resources (e.g., lakes, rivers) and priority environmental issues (e.g., water pollution) to assist in conservation of environmental and water resources. The databases and analytical tools developed by the project will help enhance dam safety in many basins.

60. The safeguard policies triggered by the Project are summarized in Table 5.

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		T B D
Projects in Disputed Areas OP/BP 7.60		X

Table 5: Safeguard Policies Triggered by the Project

61. OP 7.50 on International Waterways has been considered because the Project includes activities in the Indus and Ganga-Brahmaputra-Meghna basins, which are international waterways for purposes of the policy. Paragraph 2 of OP 7.50 states that the policy applies to, among others, "flood control, navigation, drainage, water and sewerage, industrial, and similar projects that involve the use or potential pollution of international waterways" as well as detailed design and engineering studies for such projects. The proposed Project does not involve any of these types of activities. Paragraph 7 of OP 7.50 recognizes three exceptions to the riparian notification requirement for Project involving international waterways. One of these (paragraph 7(b)) relates to "water resource surveys and feasibility studies". In these situations the country proposing such activities includes in the terms of reference an examination of any potential riparian issues. The proposed project does not involve any feasibility studies and does include water resource surveys in the traditional sense (i.e., to guide specific infrastructure development), but does include basin and sub-basin water resource assessments. LEGEN has concluded that the Project therefore does not trigger OP 7.50[3].

G. World Bank Grievance Redress

62. Communities and individuals who believe that they are adversely affected by a World Bank (WB) supported project may submit complaints to existing project-level grievance redress mechanisms or 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 World Bank's attention, and Bank Management has been given an opportunity to respond. For information on how to submit complaints to the World Bank'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.

[3] During Hydrology Project Phase II, real time DSS was provided for Indus River Basin, and considering the nature of work, OP7.5 was not triggered.

Annex 1: Results Framework and Monitoring

Country: India

Project Name: National Hydrology Project (P152698)

Results Framework

Project Development Objectives

PDO Statement

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

These results are at	Project Level

Project Development Objective Indicators (Target Values will be updated at appraisal)

Indicator Name	Baseline	Cumulative Target Values									
		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	End Target
Direct project beneficiaries (Number) - (Core)	1 million										5 million
Female beneficiaries (Percentage - Sub-Type: Supplemental) - (Core)	25%										35%
Operational hydromet stations integrated with centralized database (Number)	865.00										5000
Water information products and/or services available to stakeholders (Number)	5.00										20.00
Implementing agencies achieving benchmark performance levels (Number)	2.00										25.00

Intermediate Results Indicators

Indicator Name	Baseline	Cumulative Target Values									
		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	End Target
Operational SCADA management systems (Number)	0										15
Unique water data downloads (Number)	19000										200000
Online National Water Applications (Number)	2										8
River Basin with Dynamic Water Resource Assessments (Number)	1										20
Streamflow Forecast stations integrated with weather forecast (Number)	20										400
Reservoirs operation assisted by inflow forecasting models (Number)	50										200
Person-days of Training (Number)	400										10000
Institutions with at least 50% staff in relevant divisions trained in river basin modelling or flood forecasting (Percentage)	6										60
Implementing Agencies integrated with National database (Percentage)	0										50

Indicator Description

Project Development Objective Indicators

Indicator Name	Description (indicator definition etc.)	Frequency	Data Source / Methodology	Responsibility for Data Collection
Direct project beneficiaries	Direct beneficiaries are people or groups who directly derive benefits from an intervention (i.e., children who benefit from an immunization program; families that have a new piped water	Annual	IA divisions	NPMU MIS

	connection). Please note that this indicator requires supplemental information. Supplemental Value: Female beneficiaries (percentage). Based on the assessment and definition of direct project beneficiaries, specify what proportion of the direct project beneficiaries are female. This indicator is calculated as a percentage.			
Female beneficiaries	Based on the assessment and definition of direct project beneficiaries, specify what percentage of the beneficiaries are female.	Annual	IA divisions	NPMU MIS
Operational hydromet stations integrated with centralized database	Operational Hydromet stations would be the systems which are collecting and transmitting the data. The centralized database would refer to centralized Hydromet center at State or central level	Annual	WRIS	IA
Water information products and/or services available to stakeholders	Water information product/services would include: River basin information systems at state and national levels, weather forecasting, Hydrologic design aides, Water resources assessment reports for various basins. Currently Krishna and Bhakra system has online flood forecasting systems.	Annual	NWRIC	WRIS both state and Central
Implementing agencies achieving benchmark performance levels	Benchmark Indicators would include: project performance, trained staff and capacity in flood management, monitoring and data management, water resources modeling and analysis. The agencies performing satisfactorily would be considered in this indicator.	Annual	NPMU will compile the performance	IAs

Intermediate Results Indicators

Indicator Name	Description (indicator definition etc.)	Frequency	Data Source / Methodology	Responsibility for Data Collection
Operational SCADA management systems	Number of reservoir/barrages equipped with the SCADA and systems are being operated.	Annual	State MIS	State IAs

Unique water data downloads	Number of unique downloads by individuals at State or central WRIS or other products from websites by implementing agencies.	Annual	NWRIC	WRIS both state and Central
Online National Water Applications	The applications at WRIS could include online River basin information system, grid format weather forecast, ET estimate, rainfall statistics; runoff estimate; watershed, land use etc.	Annual	NWRIC	WRIS both state and Central
River Basin with Dynamic Water Resource Assessments	The assessment is in progress. The framework will be given to states to implement the assessment on regular basis. The river basin/sub-basins with dynamic water use and water availability estimates would be considered in this indicator.	Annual	States	IA
Streamflow Forecast stations integrated with weather forecast	This refers to key gauge stations for flood prone area and reservoirs for irrigation management.	Annual	WRIS	CWC and state IAs
Reservoirs operation assisted by inflow forecasting models	The number of reservoirs/barrages operated using the inflow forecast will be considered in this indicator. Currently >40 and 3 reservoirs are operating in Krishna and Bhakra systems respectively.	Annual	States MIS	State IAs
Person-days of Training	This would be equal to Number of trainings * number of days of a training*number of trainings.	Annual	MIS of NPMU	IA
Institutions with at least 50% staff in relevant divisions trained in river basin modelling or flood forecasting	The staff may belong to other relevant divisions.	Annual	IA	PMU MIS
Implementing Agencies integrated with National database	Number of implementing agencies exchanging the database with centralized system.	Annual	India WRIS	National Water Data Center

Annex 2: Detailed Project Description

INDIA: National Hydrology Project

Project Area

1. This a national project that will cover all of India. All States and Union Territories will participate, given their constitutional mandate for water resources management. Central agencies will also participate, given their roles in providing technical guidance in water resources management to the states, coordinating water management across states, and fostering a river basin approach to water resources management.

Project Beneficiaries

2. The project has three groups of direct beneficiaries:

(i) The central and state agencies responsible for surface and/or ground water planning and management, including river basin organizations.
(ii) The central agencies responsible for meteorology, survey and remote sensing which provide support to water resources management.
(iii) Rural and urban water users, and those affected by floods and droughts - especially poor, small and marginal farmers.

3. Indirect beneficiaries include stakeholders across the energy, environment and agriculture ministries, research and educational institutions, NGOs, civil society organizations and the private sector.

Project Scope

4. The project builds upon the prior investments under HP-I and HP-II, which were focused in the peninsular states of India. These 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.

5. NHP will span states that benefitted from HP-I and HP-II investments and states that were not included in earlier projects – notably those of the Ganga and Brahmaputra basins. In the new states investments will be needed move beyond existing basic infrastructure, following the approaches developed in the earlier projects. For HP-I and HP-II states investment will focus on increased use of data in water planning and management. A four-pronged strategic approach will be adopted:

(i) **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 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 nation-wide.
(ii) **Enhancing Analytical Tools:** The project will develop and demonstrate tools for water resources assessment, hydrologic and flood inundation forecasting, water infrastructure operations, ground water modeling, and river basin and investment planning.

(iii) **Transforming Knowledge Access:** The project will build on the dramatic advances in internet, mobile devices, social media and other communication tools to modernize access to and visualization of customized water information by different stakeholders.

(iv) **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 in order to effectively leverage the technology investments.

Project Principles

6. The following principles will guide all project activities:

(i) **River Basin Approach:** The project will strongly promote multi-state coordination for river basin planning, flood management and reservoir operation in large multi-state basins, as well as for cross-boundary aquifer management. In both planning and management the project will foster integration across surface and groundwater and across water quantity and quality.

(ii) **Centre as Facilitator:** The project is designed so that central agencies empower the states in water management through provision of technical support. Central agencies will:

a. Support technical evaluation of hydromet systems while states customize systems according to need, and then procure. A framework agreement will facilitate this.
b. Establish a national water information system while supporting state customization.
c. Provide web-based database management software and cloud server at no cost to states.
d. Establish flood forecasting system and train state agency staff in application for state-level decision making.
e. Facilitate water resources assessments and train state agency staff in to manage their own water at sub-basin scale.

(iii) **Data standards and protocols:** Standardized data storage formats and data transmission protocols and procedures will be adopted, together with common data storage systems and information dissemination platforms to improve data sharing.

(iv) **Software standardization:** The project will adopt a standardized approach to principal software systems, including database, GIS platforms and IT system design. Systems will be generic but will allow customization to meet the agency needs.

(v) **Data Quality and Open Access:** The project will promote accurate measurement, data checking and validation, and open data access, through provision of tools and training.

(vi) **Flexible Design:** The project will adopt a flexible approach with periodic review of state resource allocation to meet the varied and changing requirements of different state agencies.

(vii) **Learning and Leadership:** The project will develop capacity through training, cross-learning between more advanced and new project states, and via collaboration between central and state agencies. Centers of excellence will be supported establish high-level expertise that is accessible and relevant to state agencies.

Project Phasing

7. The project will be implemented in a programmatic mode where the project will support strengthening of the system and the ministry will support the operation of the system in long run. Differences between those agencies that have already participated in the Hydrology Project and the new agencies will be managed through appropriate levels of ambition in each agency’s work plan, and through various support arrangements made for project implementation. Two mid-term

reviews are planned to allow for adjustment of agency work plan and to provide any needed re-focusing of the project.

Project Components

8. 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 capacity and policy and planning capacity (Figure 1). 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 decisions support systems) to transform data into information. The project, thus, spans the value chain from water resources data through to decision making capacity in water resources planning and operations (Figure 1). Beyond the project, this is expected to lead to improved water resources decisions (operations and planning) generating greater economic, social and environmental benefits from the management of a limited water resource.

9. The project will have four components: A – Water Resources Data Acquisition; B – Water Resources Information Systems; C – Water Resources Operations and Planning; and D – Institutional Capacity Enhancement. These components (and their sub-components) map across the conceptual framework, with Component C spanning the application of systems/tools to generate water information products, and Component D encompassing the strengthening of both technical and planning/policy capacity (Figure 1).

Component A: Water Resources Data System (USD 147M)

10. Component A has two sub-components: (i) water data acquisition systems, and (ii) national and state water data centers. It will involve some central agencies and all participating states. Central agencies will provide overall coordination and guide (i) surface water monitoring network design, (ii) instrumentation selection and commissioning, and (iii) data validation and quality control.

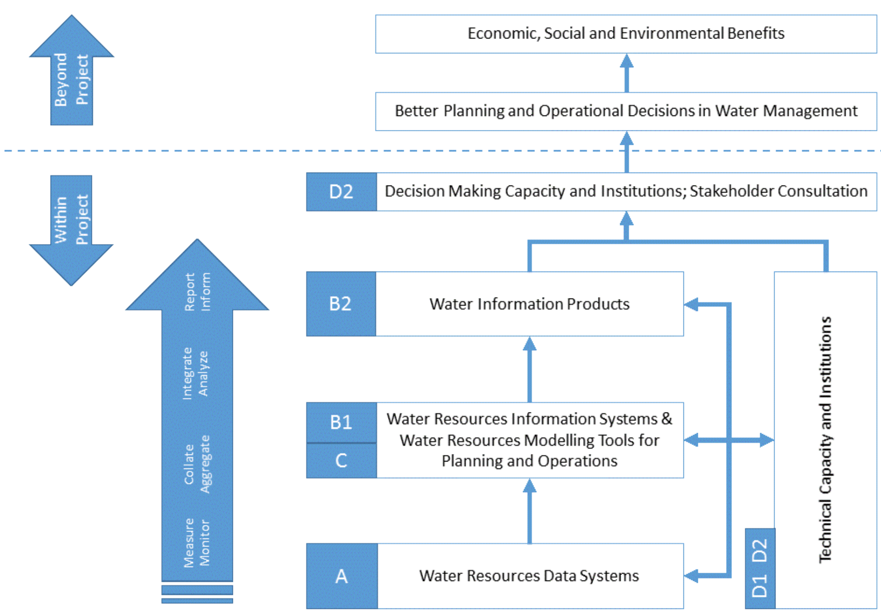

Figure 1: Project conceptual design showing components/sub-components.

Sub-component A1: Water Data Acquisition System

11. Sub-component A1 will improve the extent and reliability of water resources data through automated/digitized and real-time communication systems (Figure 2 and Table 1). The project will support installation of monitoring systems and civil works required to setup these systems. The systems could be for manual or automated measurements. Hydromet networks will encompass meteorological, hydrological (surface and groundwater) and water quality measurements. The emphasis will be on real-time data collection and telemetric transmission for use in 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, in water quality analysis laboratories, and in SCADA systems for improving the real-time operation of reservoirs and canal systems. Surveys of erosion and sedimentation, aquifer properties and river geomorphology will be undertaken.

12. A typical real-time hydromet system will include sensor/s, data logger, power source (solar/battery) and telemetry system (Figure 2). The sensors will measure a range of meteorological, surface water, ground water, and water quality parameters.

13. 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.

14. Surface water monitoring will include monitoring inflows, storage and outflows for rivers, reservoirs, canals, tanks and wetlands as well of 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 (e.g., gauge wells, equipment rooms, cable ways, and boats). River/Canal water monitoring sites are categorized with a combination of various parameters-water level gauge (G), water level and discharge (GD), sedimentation (S) and water quality (Q). The project will support real-time monitoring and controlled operation of reservoir/canal gates to manage floods and irrigation scheme operation. This will involve measurement of water levels in reservoirs and off-takes (spillways and canals) and Supervisory Control & Data Acquisition (SCADA) systems for reservoir/canal gates.

15. 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 GSM/GPRS telemetry proved to be successful for automated monitoring. In new project states the density 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.

16. A range of telemetry systems will be used, as appropriate in different situations, including GSM/GPRS, VSAT and INSAT. For fast, reliable and frequent transmission (e.g. for flood forecasting), satellite-based systems (INSAT and/or VSAT) will be used. CWC has offered use of its existing earth station for INSAT data acquisition. In other situations the GSM network will be used where available. CWC will customize the e-SWIS software for real-time data acquisition from INSAT, VSAT and GSM, meaning states will not be restricted to using sensor-specific software for data downloads and storage. Some of the existing manual systems will be upgraded to near real-time through SMS or GPS-enabled smartphone apps for gauge readers. The project will also explore "crowd-sourcing" of data by equipping, motivating and training local communities for surface and groundwater monitoring.

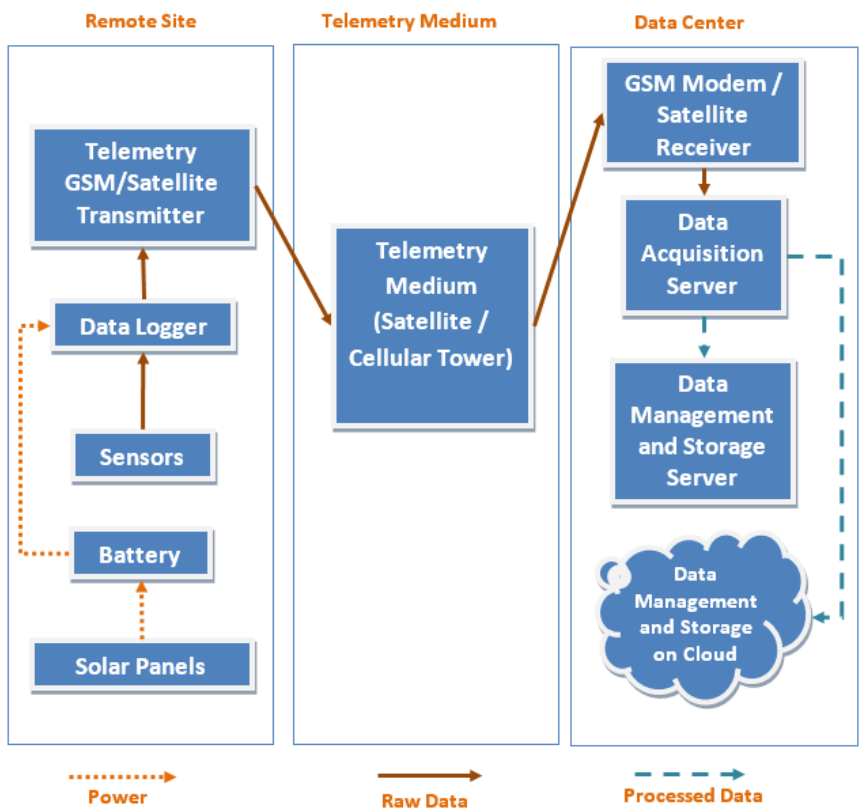

Figure 2: Schematic of real-time data transfer system

Category	**Type of Station**	**Number**
Meteorological	Rain gauges	2452
	Automatic Weather Stations	559
Surface Water Level Monitoring	Rivers	943
	Dams / barrages (Integrated)	550
	Canals	423
	SCADA in irrigation systems	50
	Total	**1966**
Groundwater	Groundwater level/flow monitoring	5744
Water quality Sampling	Water quality sampling Sites	1781

Table 1: Tentative numbers of WRDAS proposed under the project

17. Sub-component A1 will also improve local understanding of water resources through site specific surveys (including river cross-section surveys, ground-water/geo-physical/hydro-geological surveys, water quality surveys, and erosion/sedimentation). Support will be provided for work on geomorphology, lithology and site characteristics. It is expected that these activities will primarily be implemented through operational support for government agencies and consulting and non-consulting services.

Sub-component A2: State and National Water Data Centers

18. Sub-component A2 will provide infrastructure, software and equipment for data management from automated and manual systems. This will include support for: (i) construction/upgradation of data centers primarily for new states to accommodate staff and serve as hub for both real-time and long-term data quality management; (ii) information technology equipment and software to receive and process data; (iii) data rescue systems for digitizing historical processing of data and records; (iv) hydrologic instrumentation facilities for testing and feasibility assessment of instrumentation, hydromet design, and to provide quality control over installations; and (v) water quality laboratories (Levels 1, 2 and 2+) for water quality analysis and testing of field monitoring equipment.

Component B: Water Resources Information Systems (USD 48M)

19. Component B has two sub-components: (i) web-based water resources information systems, and (ii) water resources information products. It will facilitate the process of managing and integrating database and information from various sources and regions including observation network developed in Component A, as well as remote sensing data, and data from other departments to facilitate online dissemination of integrated information. The online information will be anchored through web portals including centralized IndiaWRIS and water information systems at sub-national/River basin levels. National and state agencies and river basin organizations will be responsible for their respective web portals and will facilitate the exchange at intra and inter department levels.

Sub-component B1: Web-based Water Resources Information Systems

20. Sub-component B1 will develop or strengthen web-based information systems at central, regional, river basin and state levels, including further strengthening of existing centralized web-enabled spatio-temporal India-WRIS, develop protocols for integration with State-WRIS (S-WRIS) and establish sub-national level chapters. The platform would facilitate access to integrated information at River basin scale to states. Web management services will be introduced to enable the use of data from different servers and centers, and support provided for the development and customization web portals, mobile apps, social media, online modeling, and other knowledge management services. 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. National and state WRIS will be supported by standardized hydrological data acquisition and processing software to facilitate streamlined data acquisition, data entry, compilation, validation and routine analysis to enhance the quality and reliability. During Hydrology Project II, various web-based centralized database management software were developed, for entry, validation, storage and processing of surface (e-SWIS), groundwater (e-GEMS) and water quality (e-WQIS) data. These will be further developed along with 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 amongst agencies will be facilitated through MoUs that will specify which information can be publically shared. These will build on protocols developed by central agencies (IMD, CWC, CGWB and CPCB) for inter-agency 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. Centrally there is a plan to setup up National Water information center which will coordinate integration of various data and applications and cater the need of states.

Sub-component B2: Water Resources Information Products

21. Sub-component B2 will include (i) generation of high-resolution topographic surveys for priority areas for flood or development; (ii) generation of additional spatial information though field survey, geotagging of various objects (water bodies, wells), and digitation of existing maps and integrating with survey of India Maps; (iii) earth observation data products (e.g. using GeoNetCast and other products) with the support of NRSC and CWC, (iv) integration and improvement of ensemble forecast products (e.g. weather, flow, flood/drought); and (v) web-based analytical tools (e.g. for monitoring/forecasting various parts of the hydrologic cycle in a basin perspective, like precipitation, snow accumulation, snowmelt, glaciers, glacial melt, glacial lakes/GLOFs, evaporation, evapotranspiration, land use, runoff, flooding, ground water processes, water quality, catchment water budgets, water accounting, etc.), 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.

22. Sub-component B2 will support synthesis publications and interactive products and services to improve communication to stakeholders. This may include hard copy and electronic newsletters, annotated bibliographies, metadata compilations, factsheets, Atlases, National, Basin or Sub-National Water Accounts or Water Resources Assessments, State of the Basin or other synoptic reports on particular locations (like national, basin, regional, state, or other levels) or themes (like water resources, ground water, water quality). In addition, the sub-component will generate interactive or other digital products such as videos/multi-media products, interactive spreadsheets/toolkits, interactive atlases, benchmarking systems, web portals and mobile apps that will help organize information and knowledge services in a customized manner. Emphasis will be placed on improving the quality of and access to water information. Knowledge portals will provide access to documentation, online mapping, online training, social-media networking, and visualizations.

Component C: Water Resources Operation and Planning Systems (USD 56M)

23. Component C will develop and deploy modeling and decision support tools for improved water resources operations and planning, undertake a series of "purpose-driven studies" 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. There will be close coordination between Components B and C on the use and generation of information systems and knowledge products/applications. Models will be developed and applied by CWC and CGWB, using resources from the international consultancy 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 sub-models to improve the representation of local catchments within a river basin modeling system. A centralized modelling framework will be integrated into IndiaWRIS to provide an open access modelling. A "adapter module" will allow linking of legacy models. 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 reservoir and field levels. Component C has four sub-components: (i) river basin modelling, (ii) flood forecasting and reservoir operation, (iii) irrigation design and scheme operations, and (iv) purpose-driven studies.

Sub-component C1: River Basin Modeling

24. Sub-component C1 will develop river basin models and decision support systems to support river basin planning and water resources assessments. This will include modelling 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. Water resource assessments as a model output will contribute to the development of plans for irrigation development, considering patterns of water availability, and will coordinate with the PMKSY scheme. In case the additional monitoring systems are required to improve this assessment, they will be supplemented through component A. Various knowledge products based on water accounting at various spatio-temporal scales (watershed-Basin levels and daily to seasonal) may include: water availability, soil moisture status, irrigated area, crop ET, flood affected, and drought affected areas. These will be published via web-portal provided in Component B.

Sub-component C2: Streamflow Forecasting and Reservoir Operations

25. Sub-component C2 will develop models and decision support systems for streamflow forecasting for flood and irrigation management integrated with reservoir operations. The models for streamflow and reservoir inflow forecasting will be developed by 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 tools with integrated reservoir operation systems to optimize reservoirs for irrigation supply and hydropower generation. States will be encouraged to collaborate with regional and international technical support for setting up reservoir operation systems.

26. Included will be forecasting models (for weather, flow, inundation) ranging from now-casting to seasonal forecasting. Real-time tools and operational models will be developed to improve reservoir operations, scaling-up HP-II experience with real-time decision support systems (e.g. for Bhakra-Beas Basin and Krishna Basin in Maharashtra). Sub-component C2 will also develop tools for flood planning, including flood risk mapping, to guide floodplain zoning and investments in hard and soft flood mitigation measures.

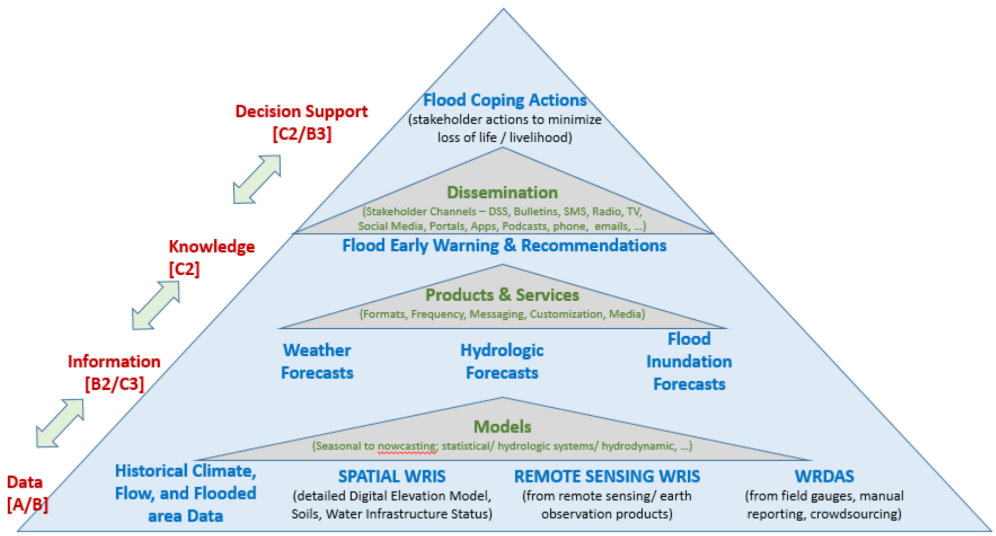

Figure 3: Flood forecasting system and interactions amongst project components.

Sub-component C3: Irrigation design and Operation

27. 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.

28. 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. Hydrological Design Aids developed under HP-II will be customized for state use.

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

(i) **GIS/remote sensing:** real-time information on will be supplemented by soil moisture deficit from satellite imagery will be used to determine reservoir releases and irrigation schedules. NRSC has developed a preliminary system that can be further developed further.

(ii) **Analytical tools:** the project will investigate conjunctive use of surface and groundwater to improve irrigation efficiency, and develop tools for improved irrigation scheduling.

(iii) **Benchmark irrigation system:** Water and land Management Institutes (WALMIs or equivalent state institutes) will be supported to benchmark irrigation systems and to promote and monitor community water management.

(iv) **Community-based water management:** Strengthened Water Users Associations will be used to improve water management in tertiary canals and groundwater systems and to improve water use efficiency.

Sub-component C4: Purpose-Driven Studies

30. Sub-component C4 will build support for purpose driven studies (PDS) and analytical tools to fill critical water resources knowledge gaps. The PDS program will be managed by NIH in collaboration with IAs. A competitive element is expected in the selection of potential PDS, and

collaboration will be encouraged between institutions in the conduct of selected PDS. Emphasis will be placed on the dissemination and discussion of completed PDS, to ensure these guide water resources development and management. The PDS program is expected to cover surface and groundwater issues, water quality, conjunctive use, sedimentation and environmental water.

Component D: Institutional Capacity Enhancement (USD 83M)

31. Component D will build capacity and capability for the technical and planning dimensions of water resources management. Component D has three sub-components: (i) water resources knowledge centers, (ii) professional development, and (ii) project management.

Sub-component D1: Water Resources Knowledge Centers

32. Sub-component D1 will construct or upgrading buildings and provide equipment to develop state-of-the-art water resources knowledge centers. These centers (co-located, where possible, with Data Centers (Component A) are expected to include: (i) a National Water Resources Knowledge Centre, (ii) sub-national centers and, (iii) special centers.

33. The National Water Resources Knowledge Center will provide a modern space to integrate the work of water-related institutions including CWC, IMD, NIH, CGWB, NRSC and CPCB. It will support training of student interns and visiting experts for enhanced knowledge collaboration including through video-conferencing, collaborative workspaces, displays, computer training rooms with distance-learning and e-learning tools, digital and document/map library and technical helpdesk services. Sub-national centers may include basin/regional centers (e.g. North East River Basin Center) or State Centers to cater for regional/state needs and issues. Special centers may include groundwater modeling centers, NIH Water Hub and regional hubs, operational control rooms, training centers, academic research and modeling centers, and Water and Land Management Institutes (WALMIs) for irrigation management.

Sub-component D2: Professional Development

34. Sub-component D2 will provide professional training, support networking of water professionals (both technical and planning) nationally and internationally, and facilitate knowledge exchange, management and communication.

35. Formal training courses (in India and overseas) 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 via degree/certification programs, study tours, workshops, e-learning tools, and distance learning. At the community level the project will identify active water management groups (water users associations) and to work with them to determine the water resources information they need in order to manage water more effectively. Information products will be developed to meet these local needs.

36. The project will develop partnerships with well-established 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 assignment/deputation international exchange programs, and improving membership in professional organizations will be encouraged.

37. The project will support workshops for knowledge exchange and professional networking – including an annual Hydrology Meeting and Expo as part of 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. Communicating consistent and meaningful messages at policy and operational levels is critical for the overall success of water institutions in India. To this end the project will invest in products and services to enhance the generation, communication and use of water resources knowledge.

Sub-component D3: Project Management

38. Sub-component D3 will provide support for effective management and facilitation of project activities and will include national and sub-national level support for technical assistance, activity management, procurement, financial management, safeguards, training, communication, monitoring, learning, evaluation, and adaptive management. Sub-component D3 will support: (i) a central project management unit, (ii) state project management units, (iii) technical quality control for hydromet equipment, (iv) monitoring and evaluation, and (v) governance and accountability.

39. A dedicated national PMU in MoWR, RD&GR will provide national level project management and develop key systems and processes for project coordination and management, including an international technical and management consultancy and establishment of MIS. Each IA will also have a PMU. The project will support out-sourced staff at state PMUs to fulfill the project management requirements according to project scope within the state.

40. A comprehensive and robust monitoring and evaluation system will be established to track implementation progress and provide meaningful reports on system level impacts. This will facilitate adaptive management by the project agencies. The HP-II system of regular performance benchmarking will be continued.

41. 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.

Annex 3: Implementation Arrangements

INDIA: National Hydrology Project

Project Institutional and Implementation Arrangements

1. NHP is a centrally funded project and will be implemented by the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD&GR). The MoWR, RD&GR, many of the central agencies and some of the state agencies have already gained substantial experience in the setting up and running of hydro-informatics systems during the implementation of HP-I and HP-II and have acquired substantial implementation capacity. Based on their experiences, the institutional model and implementation structure have been fine-tuned and suitable steps have been taken to accommodate the emerging needs of integration, access, scalability and sustainability across a larger number of IAs. These include (i) steps for mitigating the implementation bottlenecks experienced during the implementation of earlier phases, (ii) a decentralized implementation, considering the field level requirements while having balanced facilitation, monitoring and technical guidance from the center, (iii) being a centrally-funded project (taking into account the mandated roles, responsibilities and governance mechanisms in vogue), (iv) special requirements for implementing an innovative and technical countrywide information system for a vital natural resource – water, and (v) evolution of implementing institutions (including virtual platforms) for realizing a long term vision for sustainability.

2. The project implementation responsibilities will be decentralized through the respective central agencies, river basin organizations and state organizations participating in the project. While MoWR, RD&GR assumes the lead role for overall coordination and implementation, each IA will be responsible for implementation of its own activities for the project, and will be accountable for the expected deliverables.

3. A three-tier management structure is planned, both at the national and state levels, as indicated in the table and figure below. There will be two levels of management committee providing liaison, progress review and advice on project implementation. The highest level committee is for strategy and policy formulation and direction, the second level is for senior management and technical review, and the third level is for implementation and operation.

Management Level	National Level	State Level
Strategic and policy level functions	National Level Steering Committee (NLSC)	State Level Project Steering Committee (SLPSC)
Project management and review functions	NHP-Financial Review Committee (NHP-FRC); NHP-Technical Review Committee (NHP-TRC)	NHP-State Project Review Committee (NHP-SPRC)
Operation functions	**MoWR:** National Project Management Unit (NPMU) **Central Agencies:** Central Project Management Unit (CPMU) **River Basin Organizations:** River Basin Project Management Units (RPMUs)	State Project Management Unit (SMPU)

Table 1: Management and Implementation Levels

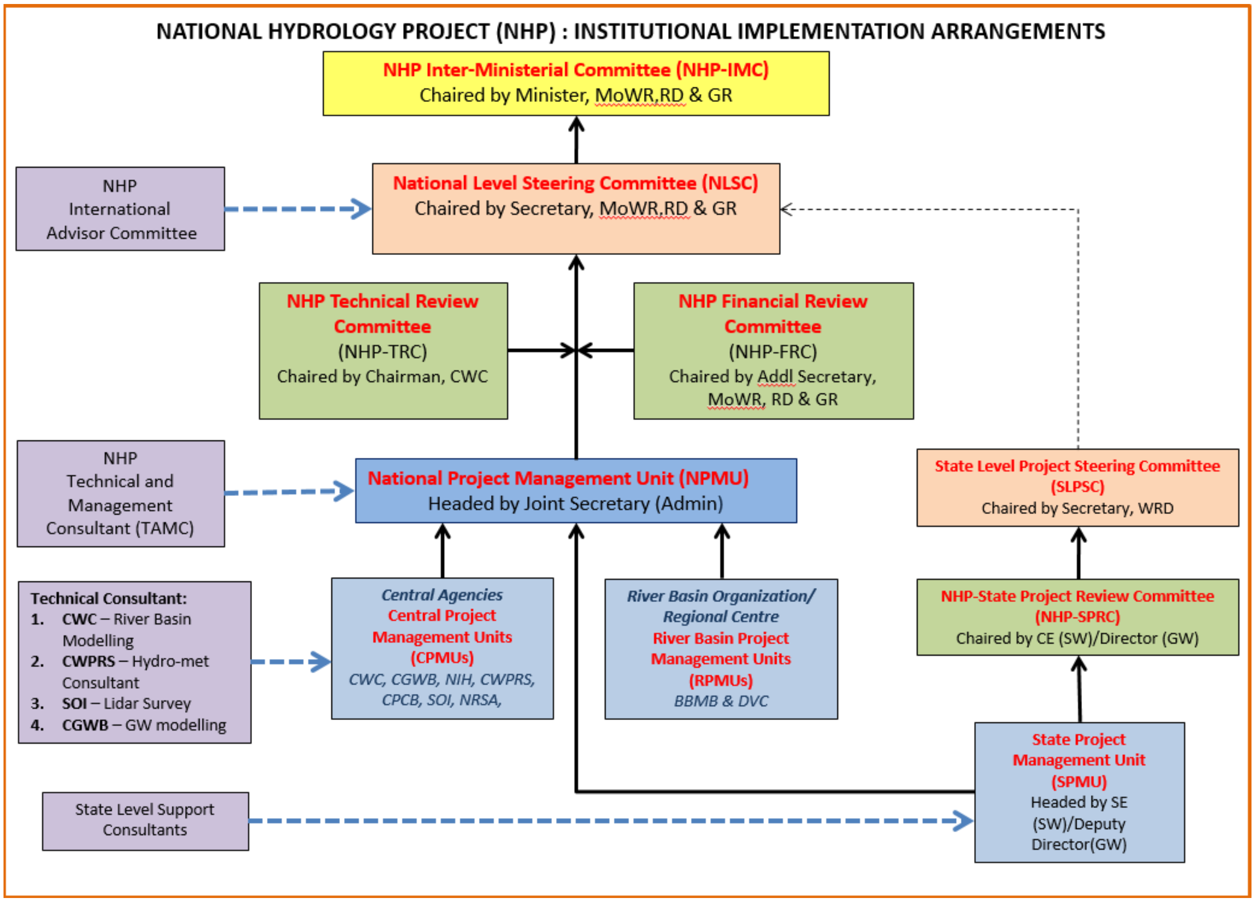

Figure 1: Institutional Arrangements in the project

I. Strategic and Policy Level

4. At the national level, the National Level Steering Committee (NLSC) will be the apex body overseeing project implementation - with administrative, management and coordination roles. The NLSC will be chaired by Secretary, MoWR, RD&GR with Additional Secretary; Chairman, CWC; Chairman, CGWB; Chairman, NIH; Chairman, CWPRS; representatives of other central agencies & RBOs and Principal Secretaries of implementing states as members and Joint Secretary (Admin) MoWR, RD&GR as Member Secretary. The NLSC will meet at least once every year and review the progress of NHP and provide strategic oversight and guidance for future implementation. The key roles of NLSC are (i) overall administrative, management and financial control of the project, (ii) reviewing project progress and providing guidance/policy direction for improving project implementation, (iii) providing policy direction for data sharing protocol for India-WRIS and ensure implementation of River basin plans; (iv) ratifying decisions that remain unresolved at NHP-FRC and NHP-TRC level (as appropriate) and, (v) resolving inter-agency coordination issues.

5. State Level Project Steering Committee (SLSC) will be chaired by the Secretary of the appropriate Irrigation or Water Resources Department under which the state's surface and ground water agencies are placed. In case of separate departments handling SW and GW activities, the state would either nominate a nodal Secretary for NHP who would function as the Chairperson of

SLSC and represent the state's interest in the NLSC or, alternatively, the Secretary, SW and Secretary, GW would alternately hold the Chairmanship on an annual rotation basis. In either case, the SLSC would include the Secretary of the concerned Water Resource Department and the Finance Secretary, as well as regional heads of the participating central agencies active in the state as well as the Nodal Officer of the RBOs, senior representatives of selected Water User Departments (e.g. Agriculture, Power, Environment and Forest, Urban and Rural Development, Fisheries, etc.), and invited experts from the water sector. SLSC will handle all policy and strategy matters related to project implementation. The Nodal Officer – SPMU would be the Member Secretary of SLSC. In the case of states where the SW and GW departments are separate, the head of the SPMU from the SW and the GW departments would function as the Member-Secretary, alternating every year. SLSC would monitor the physical and financial progress of NHP at the state level and provide directions at the Strategy, Policy level and Project management level.

II. Project Management and Review Level

6. In order to provide focused advisory support to NLSC and to monitor and review the implementation of NHP on its behalf, it is proposed to constitute the NHP-Financial Review Committee (NHP-FRC) and NHP-Technical Review Committee (NHP-TRC). Both the committees will undertake focused monitoring and reviewing in their respective areas of expertise and report the progress to NLSC through the NPMU. The committees would be empowered to constitute special purpose Working Groups or Task Forces to address specific aspects of the project through time-bound activities (with clearly-defined deliverables), by engaging specialists from academia as well as from industry, as needed.

7. NHP-FRC: This committee will be responsible for reviewing and reporting the financial performance of the project to NLSC. The key roles include (i) Review project progress, annual work plan and fund flow; (ii) coordinate with state senior management to resolve financial issues; (iii) monitor financial performance regularly and recommend solutions including restructuring if needed during Mid-Term or any other important phase of project; (iv) provide performance based allocation to IAs; and (v) review audit and financial compliance of IAs to the financial and administrative requirements, for project administration and delivery.

8. NHP-TRC: The key responsibilities of the committee include (i) providing overview of the Framework Agreement for Hydromet instrumentation procurement (including development of appropriate technical specifications for instrumentation), (ii) ensuring complete implementation of data sharing policies and addressing cooperation issues in this regard, (iii) monitoring data input for data management software and reviewing their effectiveness, (iv) reviewing steps taken for ensuring data accuracy/quality control and their effectiveness, (v) monitoring progress in the development of modeling systems and software tools (as well as their roll out to state agencies), data dissemination and the use of information systems, and (vi) monitoring training and capacity building programs and their effectiveness and finally reporting to NLSC.

9. At the state level, an NHP-State Project Review Committee (NHP-SPRC) would enable better coordination between the participating agencies. It would be chaired by the Engineer-in-Chief /Chief Engineer/Director of the concerned Irrigation or Water Resources Department and, in states where SW and GW IAs report to more than one Secretary, the Chair will rotate annually between the Engineer-in-Chief (/Chief Engineer) and Director (GW) as for the SLSC. Membership of NHP-SPRC would be drawn from the participants of NHP within the state, including representatives of

the central agencies and RBOs (where applicable). In addition to co-ordination, management and review, NHP-SPRC would ensure compatibility of procedures, formats, protocols, etc. between the central and state agencies. The NHP-SPRC would have, at state level, similar technical responsibilities to those held at central level by the NHP-TRC and NHP-FRC.

10. An NHP International Advisory Committee will be formulated to provide strategic advisory to NLSC on overall project implementation, including policy and institutional aspects. The members of this committee will be drawn from internationally reputed water agencies (including academic and research institutes). The committee will meet twice a year and provide strategic advisory and guidance for NHP implementation to NLSC.

III. Project Operation Level

11. At the central level, the project will be coordinated by a National Project Management Unit (NPMU) at MoWR, RD&GR which will be responsible for overall management, fund allocation, technical and procurement support, and M&E. The NPMU will be supported by an international technical and management consultancy, with dedicated cells in each region. As required, state agencies will be permitted to hire separate technical and management consultants. The NPMU will have a strong MIS and M&E system for monitoring the project. Fund flow to states will be through MoWR, RD&GR. The NMPU will have a dedicated fiduciary desk to streamline the fund releases and will also organize the arrangement for audits to ensure the processing of claims in a timely manner. The TAMC team will consists of senior multi-disciplinary managerial and technical specialists, including water resources management specialists, institutional, program management and finance procurement specialists.

12. The project will be supported on technical aspects by central agencies including CWC, CGWB, CWPRS, CPCB, IMD, SoI and NRSC. Out of seven central IAs, two agencies (NRSC and SoI) are new to the Hydrology Project and shall require familiarization with the World Bank procedures. During HP-II, the performance of central agencies was average - partly due to delays in financial clearances. Improvements in the way these are managed, will be sought.

13. In order to provide the flood and water management solutions at a river basin scale, all states have been encouraged to join the project. The state IAs will include surface and ground water departments, or integrated water resources departments. Around 40 percent of the participating state agencies will continue from HP-II and have experience with Bank procedures. Well-performing agencies from HP-II will be acting as mentors to new states. Several new states do not have Hydromet monitoring cells and their implementation capacity in other World Bank projects has been mixed. A dedicated Hydromet cell will be a pre-requisite for joining the project.

IV Component-wise Implementation arrangements

14. **Component A:** This component will be implemented by all participating state and central agencies. Central agencies will have overall coordination and technical guidance responsibilities: CWC for meteorology and surface hydrology, CGWB for ground water hydrology, CPCB for water quality, and NIH for DSS and applied research. These agencies will also guide the design of an optimized monitoring network and will be responsible for data validation relating to their respective domains. CWPRS will serve as an R&D center and provide overall guidance on instrumentation selection, commissioning and quality control.

15. Procurement of Hydromet equipment will include procurement of equipment and integrator services, and procurement of data services with a long-term (ten years) commitment. A Hydromet specifications committee will facilitate technical evaluation through the short-listing of models of monitoring sensors/components and standardization of specifications. CWC will process the Framework Agreement for technical evaluation that will facilitate the short-listing of firms and the states will be required to use a simple procurement document for financial bids for Hydromet supply and installation.

16. Real-time data acquisition system will be facilitated by a National Water Data/Informatics Center while states will establish respective State Water Data/Informatics Centers. All centers will support data backup and archiving. The quality control and validation of data will be conducted by respective central agencies through the software supported under Component B. CWC (E-SWIS), CGWB (E-GEMS for DWLR) 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 phases.

17. CWC has offered to use their earth stations for INSAT data acquisition and to customize e-SWIS software for real-time data acquisition from INSAT, VSAT as well as GSM. States will be free to have an independent e-SWIS server or to be integrated with the CWC system (see Figure 4). CWC has a cloud server with the facility to provide 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.

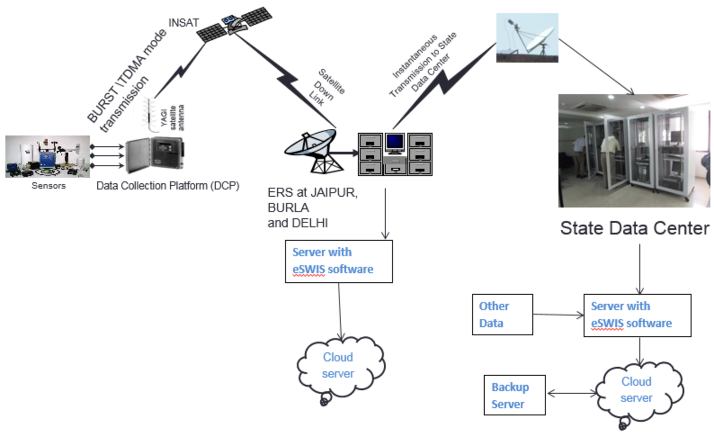

Figure 2: Real time data transmission system in state and center using INSAT technology

18. **Component B**: This component will be mostly implemented by CWC and CGWB, supported by CPCB for the management of water quality data. Upgrades of e-SWIS and e-GEMS software for managing surface water and ground water 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. Similarly, development of the IndiaWRIS will be led by central agencies- which will also facilitate and assist the states wishing to develop their own sub-systems. Procurement of additional data-sets for WRIS systems will be coordinated and supported by central agencies.

19. **Component C**: CWC will coordinate the modeling element of this component with the help of the international consultancy. CGWB will cooperate with ground water modeling work. The international consultancy 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 CWC and to establish this approach within their state with the help of centralized experts or agencies engaged directly by them. Flood forecasting systems will be upgraded by CWC for upper catchments and major river basins, while states will be responsible for their tributaries, within their own models, which will be linked with the main basin model. NIH will help develop DSS and support states with their modeling development. NIH will coordinate the PDS program of specific studies conducted by central and state agencies to resolve specific issues in each state or river basin.

20. **Component D**: NIH will be the coordinating agency for all training, with support from central technical assistance consultants. They will coordinate training on tools developed under the project, and will develop additional training programs in association with reputed national and international institutes- particularly on Hydromet, river basin modeling and ground water modeling. MoWR, RD&GR will coordinate the collaborations with international institutes and will advise staffing and institutional arrangements for centers of excellence proposed under the project.

Assessment

21. MoWR, RD&GR is fully committed to NHP as evidenced through the provision of grants to the states and the articulated goal of establishing a National Water Information Center. MoWR, RD&GR will provide 100% grants to states, thus strengthening the National Water Information Center as a repository of all water and related data. The fund allocation will be flexible and any reallocation will be done in accordance with the performance of each agency.

Type of Agencies	Number	Agencies with existing Hydrological monitoring divisions*	Agencies familiar with Bank procurement	PMUs strengthened with core team	Ready with Institutional Arrangement
States	36	31	25	27	28
UT	1	1	1	1	1
Central agencies	8	5	8	3	3
RBO	2	2	2	2	2
Total	47	39	36	33	34
Percent of total		**87***	**77**	**71**	**73**

Table 2: Assessment of implementing agencies *% represent with respect to total state agencies

22. Of total 37 state/UT IAs, 31 have already established hydrological monitoring. The six north-eastern states (except Nagaland) are yet to establish hydrology divisions. The 20 HP-II IAs have established appropriate institutional arrangements but can further improve these and streamline implementation arrangements, particularly for irrigation/reservoir management. Amongst the 20 new agencies, 9 are familiar with World Bank procurements while 11 (primarily north-eastern) will require familiarization. Nonetheless, the mission was highly impressed with the dedication of

the north-eastern states to the project – they have already nominated dedicated teams and have actively participated in project implementation training. The resulting HIS and application tools will require continuous interaction and stronger linkages with existing institutions under each state's overall water resources development and management structure. The mission recommends that new agencies 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. A Hydro-informatics Cell would 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.

23. The mission recommends that states provide the following information as part of the initial PIP to demonstrate implementation readiness: (i) Hydro-informatics Cell organogram; (ii) proposed date for Government Order institutionalizing the Hydro-informatics Cell within the overall water resources management structure of the state; (iii) number of positions within the Hydro-informatics Cell already filled-in and planned date for filling-in the rest of the positions.

24. The states and other IAs should provide, in the PIP, information on implementation arrangements for each project component - indicating the anchor person within the Hydro-informatics Cell responsible for coordination and monitoring of component activities.

25. Using World Bank technical assistance support, various learning and sharing workshops have been organized to familiarize IAs with global best practices and innovative tools - in particular, on Hydromet; ground water, surface and sub-surface geophysics; hydrological modeling and procurement. Since September 2014, 9 training events have been organized, with around 485 participants. Details on training events and participation are on the project website and are summarized in Table 3.

Event Type	**Category**	**Number of trainings**	**Number of participants**
Training/workshop	Hydromet system	3	191
Training/workshop	Hydrological modeling	2	150
Training	Ground water geophysics	2	70
Training	Procurement	2	74
Grand Total		**9**	**485**

Table 3: Type of training and number of participants

26. The CMPU/MoWR, RD&GR has initiated discussions with participating states and central agencies on project design and operation. Project consultations have evolved as a technology-driven platform (WhatsApp and email) for information exchange, coordination and consultation. New project states have been linked with prior HP states to provide project preparation advice, provide 'peer to peer' technical assistance and support exchange meetings. The cooperation of Maharashtra, BBMB, Himachal Pradesh, West Bengal, Andhra Pradesh and Telangana is particularly appreciated for hosting trainings and visits and providing guidance during visits to new states. The mission encourages IAs to continue these exchanges.

Financial Management

27. **Budgeting**: MoWR, RD&GR is the nodal IA at the center and the project would be centrally sponsored scheme with 100% grant to agencies. The amount from the center to the state would flow as Grant in Aid (GIA). The GOI will create a separate budget head for Externally Aided

Project- NHP and budget allocations for the center and Bank share will be made by MoWR, RD&GR. The states will also create separate budget heads for Externally Aided Project- NHP and annual budget allocations, equivalent to transfers expected from the center, will be made by the states. Budgets will be prepared based on the approved Annual Work Plan (AWP), which in turn will be prepared based on project needs, implementation capacities, and past performances. The AWP will be approved by the Project Steering Committee prior to the start of the financial year.

28. **Fund Flow arrangements**: The fund flow arrangements for the project will be through established country systems. The fund flow can be bifurcated into three major areas:

(i) **Fund flow to IAs**: MoWR, RD&GR will release funds into the state treasury in the form of Grant in Aid. A prerequisite for this is the state providing an equivalent budget of expected transfers from center and an approved work plan. The releases from MoWR, RD&GR will be made in two installments. The first release will be made at the beginning of each financial year, soon after the annual budget is approved by GOI and it will be 50 percent of central and Bank share. The second installment will be released based on the demand from state (usually six months after the first release) in a similar manner. This release will take into account the expenditure incurred and forecast of cash requirement for the rest of financial year. The states would need to submit a UC along with the fund request for claiming the second tranche. In case any state requires funds earlier than six months, they can submit the requisite documents along with UC and claim the second installment.

(ii) **Fund flow to departments**: At the beginning of the financial year states will provide the budget to departments. Departments will allocate the budget to Drawing and Disbursal Officers (DDOs) of implementing departments, who will disburse payments for approved project activities. All payments would be made through the state treasury. The departments would liaise with the state finance department for budget and fund flow related issues.

(iii) **Fund flow to central agencies:** The central agencies will open a separate bank account for the project and MoWR, RD&GR will release funds into the bank accounts in the form of Grant in Aid. The releases from MoWR, RD&GR will be made in two installments. The first release will be made at the beginning of each financial year soon after the annual budget is approved by GOI and subsequent release will be made based on the demand, taking into account the expenditure incurred and forecast of cash requirement for the rest of financial year. The agencies would provide UC every six months to the MoWR, RD&GR.

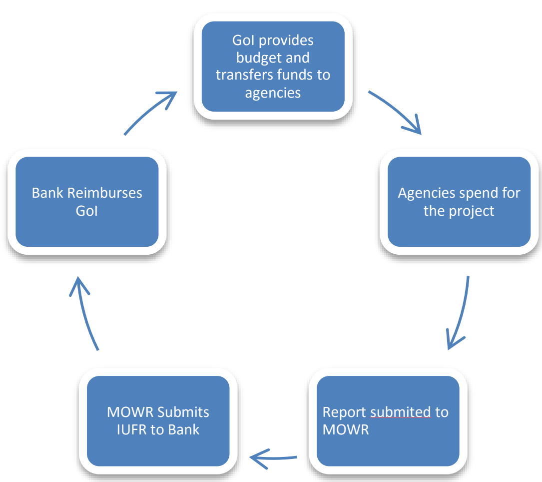

Figure 7: Fund flow cycle under the project.

29. **Accounting and Information System**: 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 (GFRs), as applicable to all transactions at the GOI/state levels. Adequate accounting records will be maintained for project transactions. The finance manual prepared under HP-II will be customized to meet the accounting and reporting requirements of the project. The MIS system developed and used during HP-II, for capturing component-wise expenditure details, will be used to meet the financial reporting needs of the project.

(i) **Accounting at departments**: The departments would maintain cash books and other relevant ledgers for the project separately for the ease of accounting, auditing, and reporting. The departments would report the expenditure in the IUFR formats to the state.

(ii) **Accounting at state level**: Each state would create a PMU to deal with this project. All accounts from the departments would be consolidated and collated at this unit and the accounts would be sent to the MoWR, RD&GR.

(iii) **Accounting at Central Agencies**: These agencies would follow the accounting system normally used by them. These agencies would maintain separate cash book and accounts for the project along with a separate project bank account. These agencies would submit the accounts and reports to MoWR, RD&GR for consolidation.

(iv) **Accounting at MoWR, RD&GR**: MoWR, RD&GR will create an accounting unit at PMU which will consolidate all the reports from states and central agencies and submit report to the Bank.

30. **Interim Unaudited Financial Reports (IUFR)**: IUFR would be the basis of disbursement. Consolidated IUFR would be submitted by MoWR, RD&GR within 60 days from the end of the each calendar quarter. IUFR formats needs to be developed and agreed by negotiation.

31. **Staffing:** FM staffing needs to be augmented at MoWR, RD&GR and in the states to carry out the compilation and consolidation of reports. This was one key weakness in the last project. At MoWR, RD&GR, a FM consultant (preferably a CA) should be hired to support the project; while in the states, either staff on deputation or commerce graduates can be hired to carry out this assignment. This needs to be discussed and agreed by appraisal.

32. **External audit arrangements:** The Project Financial Statements (PFS) will be annually audited by Comptroller and Auditor General of India (CAG). 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 would be provided by the respective auditors. The Bank would like to have one consolidated audit report for the project which is to be discussed and agreed with AG and the MoWR, RD&GR by negotiations. The audit reports are to be submitted within nine months from the end of each financial year.

33. **Internal audit arrangements:** Internal audit would be an integral part of the project design. A CA firm would be hired to carry out the internal audit of the project. The scope and the selection process of the auditors needs to be agreed by negotiations.

Disbursements

34. **Disbursement arrangements:** The GOI and states will use the budgetary resources to pre-finance project expenditures. The Bank will reimburse the project upon submission of IUFR based

on actual expenditure. The MoWR, RD&GR will submit one consolidated IUFR within 60 days from the end of each calendar quarter, which will form the basis of disbursement from the Bank. There would be no designated advance for the project.

35. **Retroactive financing**: The project is planning to execute certain contracts under retroactive financing. A separate IUFR would be submitted for claiming the retroactive expenses. The following are the Bank rules for retroactive financing:

(i) the activities financed are included in the project description,
(ii) the payments are for items procured in accordance with applicable Bank procurement procedures,
(iii) such payments do not exceed 20 percent of the credit amount, and
(iv) payments were made by the recipient not more than 12 months before the expected signing date of the Financing Agreement.

36. **Outstanding Audit reports of HP-II:** Audit reports for HP-II for the period April 1, 2014 to November 30, 2014 will become due by December 31, 2015 for submission to the Bank. In the past financial years, we have noted delays in the submission of audit reports by IAs and this could be a potential issue in project preparation process. The above audit issue needs to be appropriately addressed before negotiations of NHP.
37. Based on the above arrangements and discussions, the risk rating is being pegged as “SUBSTANTIAL”. By negotiation, if the fund flow arrangements and required FM capacity is ensured, it will be revised to “MODERATE”.

Procurement
38. 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 and Grants by World Bank Borrowers" (dated January 2011, revised July 2014) - Procurement Guidelines; and "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits and Grants by World Bank Borrowers" (dated January 2011, revised July 2014) - Consultant Guidelines, and the provisions stipulated in the Legal Agreement. The project would be subject to the Bank’s Anti-Corruption Guidelines (dated October 15, 2006, and revised January 2011).

39. **Procurement implementation arrangements**: There are presently a total of 47 IAs, which includes 8 central, 37 state-level and two RBOs. Of these, there are 27 agencies which were part of the earlier Hydrology Project and are familiar with Bank procurement policies and procedures having carried out procurement under the project. There are 20 agencies which are new to NHP, and except few, most of them have no prior experience of implementing Bank-funded projects. Presently, it is envisaged that each of the IAs would be responsible for undertaking procurements and contract management activities under the project. During project preparation and appraisal, the procurement arrangements would be finalized, after taking into account various aspects such as types of procurements, the capacities of the IAs etc.

40. **Procurement Risk Assessment:** The Procurement Risk Assessment and Management System (PRAMS) is presently being undertaken on a sample of IAs and will be finalized during appraisal.

Taking into consideration the mix of IAs, their experience of implementing Bank-funded projects, and the experience of implementation of HP-II, the procurement risk rating is "HIGH".

41. Based on the present assessment, the following measures need to be implemented, namely (a) preparation of procurement manual, (b), hiring of a Technical and Management Consultancy (TAMC) to assist in procurement, (c) hiring of procurement support consultant at the IA level where capacity is weak, (d) maximizing the use of framework agreements. However, after the completion of the risk assessment and finalization of the procurement arrangements and strategy, a final consolidated list of actions to be implemented would be drawn up and finalized during appraisal, which should assist in modifying the risk rating to "SUBSTANTIAL".

42. **E-procurement System:** The procurements under the project would need to be carried out using e-procurement systems of the IAs. The Bank has earlier carried out e-procurement system assessment against the Multilateral Development Banks (MDB) requirements, and many state/IA systems have been approved as acceptable for use under Bank-funded projects. In case there is an IA whose e-procurement system has not been assessed, then the Bank would carry out the system assessment and provide an approval.

43. **Procurement Plan and Readiness:** The draft procurement plan for the project implementation is still under preparation and will be enclosed. Each of the IA would finalize the tentative packaging and procurement plan by appraisal. As per the readiness filters, at least 30 percent of the project cost should be ready for award by negotiations. Hence, all the IAs should finalize the procurement plan, approved by the Bank, and then only initiate the procurement so as to meet the readiness requirement.

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

(i) **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 USD 10 million and would be procured following National Competitive Bidding (NCB)/shopping method. The project also envisages carrying out surveys (DEM). The procurement details of these would be further discussed during preparation and finalized during appraisal. The Standard Bidding documents of the Bank, as agreed with GOI task force (as amended from time to time) for all procurement under NCB, will be used.

(ii) **Procurement of Goods:** The project envisages procurement of different types of equipment (hydromet systems, software, RTDAS etc). The large number of IAs and the variable procurement and technical capabilities pose a huge challenge and this requires a robust procurement strategy. Based on experience and learning from the implementation of HP-I and HO-II, it is proposed that a Framework Agreement (FA) be developed for Hydromet and other equipment. The framework agreement would be both single-stage as well as two-stage procurement. The CPMU and/or central agencies will be responsible for initiating the first stage of the FA and determining acceptable manufacturers, suppliers and equipment. In the second stage, Purchase Orders are placed by the IAs as and when goods/equipment are required, after getting price quotations from the list of approved acceptable supplier list. The project envisages that certain procurements like satellite imagery and related analysis may have to be procured from government owned entities such as NRSC, Indian Meteorology Department (IMD) and SoI. The details of such procurement and their eligibility, under the

Bank financing would be discussed and agreed during appraisal. Other goods, including IT equipment and software, will be procured following ICB, NCB, shopping methods. Framework Agreements using DGS&D rate contracts can be used to procure goods up to NCB threshold, subject to incorporation of right to audit and fraud &corruption clauses. The Standard Bidding documents of the 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 Bank's latest Standard Bidding Documents (SBDs) will be used.

(iii) **Procurement of non-consulting services**: The government wishes to move from the usual practice of procurement of equipment and data collection 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 data. The procurement documents for this innovative approach, which would be a long-term agreement, would be developed after carrying out detailed market analysis.

Method of Procurement	**Thresholds for Method**	**Prior Review Threshold**
ICB (Goods)	> USD 3M	First contracts and all contracts above USD 1M
NCB (Goods)	> USD 0.1M and up to USD 3M	First contract
Shopping (Goods)	Up to USD 0.1M	
ICB (Works)	> USD 40M	All ICB Contracts
NCB (Works)	> USD 0.1M and up to USD 20M	First contracts and all other contracts above USD 10M
Shopping (Works)	Up to USD 0.1M	
ICB(Non Consulting Services)	> USD 1M	All ICB contracts
NCB(Non Consulting Services)	< USD 1M	First Contract
Direct Contracting	No Threshold; meet paragraph 3.7 of Guidelines	All contracts above 10,000

Table 4: Thresholds (USD equivalent) for prior review for procurement of goods, works and non-consulting services

45. The Prior Review Thresholds will be reviewed and updated during the implementation of the project, and modified based on the risk assessment.

46. Selection of consultants: All the consultancies required under the project are still to be finalized and the selection/hiring of such consultancies shall follow the Bank Guidelines. The Bank's Standard Request for Proposal Document will be used as a base for selection of consultancy services that are to be procured under the project. Presently, only few large value and critical consultancies have been identified: (a) Technical and Management Consultancy (TAMC), and (b) consultant for river basin flood forecasting and river assessment. In addition, consultancies will be required for updating of software and studies.

Method of Procurement	**Threshold (USD Equivalent)**	**Prior Review Threshold**
Quality and Cost Based Selection	No threshold	First 2 consultancy contract and subsequently all other contracts above 0.5M
Quality Based Selection	No threshold	
Selection Made Under a Fixed Budget	No threshold	
Least Cost Selection	No threshold	

Selection Based on Consultant's Qualifications	< 300,000	
Single Source Selection of firms	As per Consultant Guidelines Para 3.9	All contracts above 10,000
Selection of Individual Consultants	No threshold	All contracts above 200,000. In case of contract to individuals, the qualifications, experience, terms of reference and terms of employment shall be subject to prior review

Table 5: Prior Review Thresholds (USD) for Selection and Employment of Consultants

47. The project also envisages collaboration with multiple international institutes, which would be identified based on the technical expertise required.

48. The full details of the procurements to be carried out under the project would be finalized during appraisal and will be disclosed in the procurement plan. The procurement plan would list out all the procurements to be financed by the 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 Bank.

49. The procurement plan would be prepared using the Bank system "STEP". 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.

Prior Review				
Agency	**Type**	**Value (USD M)**	**No.**	**Remarks**
CWC	Framework agreement of Hydromet and WQ Lab equipment	69	1	Goods
All IA's	Hydromet and SCADA (Prior to effectiveness of framework agreement)	15	15	Goods
All IA's	Construction/Renovation of Data Centers/Training Centers	9	10	Works
MoWR	Technical and Management Consultant	15	1	Services
CWC	River basin FF and River assessment	19	10	Services
CGWB	Groundwater Modeling	1	1	Services
SOI	High Resolution DEM Survey	16	1	Services
Grand Total		**144**	**39**	
Post Review				
All IA's	IT equipment	14	1	Goods (DGS&D)
All IA's	Furnishing of PMU offices and Data Centers	7	1	Goods (DGS&D)
States	O&M of existing Hydromet installed during HP-1 and HP-II	6	10	Goods
All IA's	Construction/ renovation of hydromet stations	8	15	Works
All IA's	Construction / up gradation of water quality labs	1	50	Works

States	Stream flow forecasting and reservoir operation, River basin assessment, GW modelling etc.	33	120	Services
Total		**69**	**197**	
Grand Total		**213**	**236**	

Table 6: Major procurement packages under the project

50. **Record Keeping**: 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 notification, registers pertaining to sale and receipt of bids, bid opening minutes, Bid Evaluation Reports, all correspondence pertaining to bid evaluation, communication sent to/with the World Bank in the process, bid securities, 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, etc. Ideally, a separate file should be maintained and retained by IA for each contract.

51. **Disclosure of Procurement Information**: The following documents shall be disclosed on the ministry and IA websites: (i) procurement plan and updates, (ii) invitation for bids for goods and works for all ICB, NCB and shopping contracts, (iii) request for expression of interest for selection/hiring of consulting services, (iv) contract awards of goods and works procured following ICB/NCB procedures, (v) list of contracts/purchase orders placed following shopping procedure on quarterly basis, (vi) list of contracts following DC on a quarterly basis, (vii) monthly financial and physical progress report of all contracts, and (viii) action taken report on the complaints received on a quarterly basis.

52. The following details shall be sent to the Bank for publishing in the UNDB 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 procedure, and (c) list of contracts/purchase orders placed following DC procedures on a quarterly basis.

53. Further, 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.

54. **Review by Bank**: All contracts not covered under prior review by the Bank will be subject to post review during Implementation Support Missions and/or special post review missions, including missions by consultants hired by the Bank. For the avoidance of doubts, Bank may conduct, at any time, Independent Procurement Review (IPRs) of all the contracts financed under the loan.

55. **Frequency of Procurement Supervision:** Two missions in a year, each at an interval of six months, are envisaged for procurement supervision of the proposed project.

Contract Management

56. 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 multi-skilled TMC consultant, engaged to

provide overall implementation support and monitor all works, goods, non-consultancy and consultancy contracts. Moreover, an e-contract management system will be developed to monitor overall project progress, critical contract management milestones and reporting.

Environmental and Social (including safeguards)

Monitoring & Evaluation

57. The project will have monitoring system in three categories: Project management, physical and financial progress; and project indicators. The project indicators are listed in Annexure 1.

Role of Partners (if applicable)

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 defined in the SORT.

2. The World Bank's approach to implementation support strongly 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. The implementation support thus comprises: (a) Joint Review Missions; (b) regular technical meetings and visits to Implementing Agencies 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 to the Project's Components 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:

a. **Technical Inputs.** The World Bank will solicit inputs from three international experts in Hydro-meteorological Instrumentation, ICT, and Hydraulic and Hydrologic Modelling, whose support will focus on both components A & C respectively of the project.

b. **Fiduciary Requirements and Inputs.** Training will be provided by the World Bank's financial management specialist and the procurement specialist before Project effectiveness and during project implementation. This will allow building capacity among implementing agencies in matters of FM and procurement, particularly regarding World Bank procedures. Supervision of financial management arrangements will be carried out as required as part of the project supervision plan and support will be provided on a timely basis to respond to project needs. Procurement supervision will be carried out on a timely basis as required by the project.

c. **MIS:** Considering the large number of implementing agencies (47) and geographical area of the project, the support would be provided to the implementing agencies in MIS for procurement, disbursement and monitoring of the project progress.

d. **Safeguards**: The Bank will monitor compliance with the Social Management Framework and Environment related courses during the implementation support missions, and technical guidance will be provided accordingly.

5. The main focus of implementation support* is summarized below.

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	
1	Procurement Specialist	3	3	3	2	1	1	1	1	
2	FM Specialist	2	2	1	1	1	1	1	2	
3	M&E Specialist	3	3	2	2	2	1	1	2	
4	MIS Specialist	4	4	4	4	4	1	1	1	
5	Economist	1	1	1	1	1	1	1	1	
6	Social Specialist	1	1	1	1	1	1	1	1	
7	Environment Specialist	1	1	1	1	1	1	1	1	
8	Capacity Building Specialist	2	2	1	1	1	1	1	1	
9	Institutional Specialist	2	2	1	1	1	1	1	1	
10	Water Resources Specialist	12	12	12	8	8	6	3	3	
11	Hydro-met Instrumentation Specialist	8	8	4	4	4	2	0	0	
12	SCADA Specialist	1	2	2	1	1	1	0	0	
13	Groundwater Management Specialist	2	2	2	2	2	1	1	1	
14	Co-TTLs	12	12	12	12	12	8	8	8	
	Total	**54**	**55**	**47**	**41**	**40**	**27**	**21**	**23**	**308**

*Implementation Support in Staff Months

Annex 5: Economic and Financial Analysis
INDIA: National Hydrology Project

1. It is widely acknowledged that, "the importance of Hydromet Services in the form of weather, climate and hydrological forecasts is in many ways self-evident. Across the world, hundreds of thousands of weather forecasts, severe weather warnings and climate predictions are issued every year. These forecasts are used by myriad users, ranging from households to firms to government agencies."[4]

2. The aim of the NHP is to support GOI to better manage its water resources through improved acquisition, collection and collation of reliable and real-time data, as well processing and analysis that create information products and decision-support systems (DSS) to improve both the operations of water infrastructure and water resources planning processes at all levels – from local up to river basin. These tools and systems would not only lead to more efficient water resource allocation and the resolution of water conflicts, but also support the planning and implementation of programmes for rural development (such as in the Prime Minister's Krishi Sinchayee Yojana [PMKSY]) as well as industrial, urban (e.g., in Smart Cities) and general economic development.

3. While HP-I covered nine states with the support of six central agencies and HP-II was implemented across thirteen states with eight central agencies, the NHP will be implemented across India in 28 states and union territories and involve ten central agencies. It builds on the foundation established by HP-I and HP-II – which were pioneering projects in improving instrumentation, data flows and information generation for operations – but aims to go far beyond these not only in scale but also in scope by providing decision-makers, for the first time, with reliable Hydromet information (the basis for critical decisions on water infrastructure operations and planning), with analytical tools (for prediction and forecasts), and with institutional structures that deliver relevant and timely information to end users.

METHODOLOGY

4. Determining how much investment should be made in real-time Hydromet and decision-support systems requires an analysis of the full range of social, economic and environmental costs and benefits associated with establishing, operating and using such systems.[5] This is a non-trivial matter – particularly as regards the valuation of benefits – due to issues associated with 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, amongst others.

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[4]Malik, A. S., Amacher, G. S., Russ, J., Esikuri, E. E., &Ashida Tao, K. (2014*Framework for Conducting Benefit Cost Analyses of Investments in HydroMeteorological Systems,* [pdf] Washington DC: World Bank available at https://openknowledge.worldbank.org/bitstream/handle/10986/21095/929580WP0P14940sional0paper0series0.pdf?sequence=1)

[5] This requires careful attention to detail (see Malik et al., *op cit.*, WMO (2015) *Valuing Weather and Climate: Economic Assessment of Meteorological and Hyrological Services* [pdf] Geneva: World Meteorological Organization (with the World Bank Group, United States Assistance for International Development (USAID) and Global Facility for Disaster Reduction & Recovery (GFDRR) (http://www.wmo.int/gfcs/sites/default/files/wmo_1153_en.pdf),and WB (2010) *Cost Benefit Analysis in World Bank Projects*, [pdf] Washington DC: World Bank (http://siteresources.worldbank.org/INTOED/Resources/cba_full_eval.pdf) as benefit cost analysis findings can vary widely, depending on contexts and purposes (see, for instance, Hamilton, S. (2015), *The Value of Water Monitoring* [eBook], Vancouver: Aquatic Informatics, p. 32, (http://aquaticinformatics.com/news/ebook-value-of-water-monitoring/).

5. A number of studies have tried to estimate the benefits associated with Hydromet systems in the last few decades, but as Pielke and Carbone (2002)[6] and Morss et al. (2008)[7] show, knowledge about the value of benefits associated with hydrological information is still patchy and incomplete, making accurate evaluation very difficult. Malik et al. (2014) details three of the more widely accepted methods that have been used for benefit-cost analysis (BCA) of Hydromet systems:

(i) **Benchmarking:** This simple to use and relatively less time-consuming method analyses the average annual losses (as a proportion of GDP) and estimates of 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, GDP may not be reliable reported. Lastly, this approach is too aggregate to evaluate specific benefits of information that may be important to Hydromet targeting or location.

(ii) **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.

(iii) **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.

6. The BCA presented here is a modified version of the sectoral approach that combines historical data and expert opinion. The first step is to identify the wide range of benefits likely to be generated by project investments. These benefits are then classified into three broad categories (not measured, measurable but minor, and measured), each of which is described. The two major types of measured benefits from improved Hydromet systems that are formally included in the BCA and detailed below are: (1) flood damages that could be avoided and (2) additional water availability for hydro-power generation, irrigation, drinking water and industrial water supplies, resulting from improved operation of reservoirs. The costs are taken as the full project costs, including government contributions, spread over 8 years. Given the long-lived nature of investments, the BCA is conducted over a 25-year time period, with benefits assumed to be generated from year 9 of the project. Both a 12 percent and a 10 per cent discount rate are used. Finally, sensitivity analysis is conducted to analyze the robustness of the results to variations in benefits and costs.

BENEFITS

7. The Implementation Completion Report for HP-II (the predecessor of the NHP) provides an in-depth discussion of the benefits that were generated under that project and can be expected to be consolidated and scaled up under the NHP. These include benefits at three levels:

(i) At the national / central level, improved water information allowed for improved water resources assessments; use of nation-wide standardized planning and design procedures; improved technical basis for project review and approval; support for the development and

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[6]Pielke, Jr., R., & Carbone, R. E. (2002) Weather impacts, forecasts, and policy: An integrated perspective. *Bulletin of the American Meteorological Society*,*83*(3), 393-403.

[7]Morss, R. E., Demuth, J. L., &Lazo, J. K. (2008). Communicating uncertainty in weather forecasts: A survey of the US public. *Weather and forecasting*,*23*(5), 974-991.

implementation of national and state water policies; improved inter-state coordination on related sector issues; non-disputable data sets to help resolve inter-state water disputes; improved water resources management; and improved uses of data amongst all users.

(ii) At the state and basin level, improved water information allowed for improved water resources planning and design of water-related infrastructure and management options; improved groundwater management; reduced vulnerability to and enhanced management of droughts and floods; improved management of reservoirs and thereby improved hydropower and irrigated agricultural productivity; reduced impact of poor water quality on public health; improved state water policies and regulations; and improved awareness on the scarcity and importance of water leading to its more efficient use. Many of these contribute not only to growth, but also to poverty reduction.

(iii) At the project and sub-basin level, improved water information allowed for improved design and environmental impact assessment, improved groundwater impact assessment and aquifer management, and supported water use efficiency of tanks and reservoirs, hydropower generation and irrigation water productivity and optimization of watershed management interventions.

8. The discussion in the ICR is necessarily qualitative in nature – although supported by many concrete cases – due to a lack of data and other measurement issues. Nonetheless, these represent 'real' and in many cases substantial benefits, which are expected to continue and indeed, grow, under the NHP.

9. In order to conduct the BCA, the starting point for this EFA is to look across the vast array of potential benefits (many of which are of the same nature as those in the NHP-II ICR) and identify those expected benefits that can be measured and monetized with some degree of confidence. Of these, the 'major' benefits are formally included in the BCA, while those that are deemed to be 'minor' are presented and discussed. However, it should be highlighted 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, flood management) are included in the BCA, the likely 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.

10. Table 1 provides a snapshot of the three types of expected benefits -- not measured, measurable but minor, and measured. These are presented by the four key components of NHP – modernizing monitoring systems, enhancing analytical tools, transforming knowledge access and modernizing institutions. This 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 the table below with 'modernized institutions' (e.g., through training and capacity building) cannot be generated without modernized monitoring systems and enhanced analytical tools. Each of these types of benefits is discussed further below.

Project Component	**Project Benefits**	**Treatment of Benefits in Economic Analysis**
A. Water resources data systems	Reduced time and staff cost of departmental consultancies (e.g., geophysical surveys)	Measurable but minor
	Reduced time and staff cost of internal studies (e.g., feasibility studies, project proposals, etc.)	Measurable but minor

Project Component	Project Benefits	Treatment of Benefits in Economic Analysis
	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 information systems	Reduced flooding damages	Major and measured
	Increased hydropower generation	Major and measured
	Increased drinking water supplies	Major and measured
	Increased industrial water supplies	Major and measured
	Reduced costs of groundwater pumping for irrigation	Major and measured
C. Water resources operations and planning	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 inter-state water conflicts and improved cooperation	Not measured
	Social and environmental benefits	Not measured

Table 1: Project Benefits and Treatment in Economic Analysis

Benefits not measured

11. There are several intangible benefits that are difficult to measure, although potentially significant, while some other benefits have not been measured for other reasons. These include the following:

(i) Benefits of better data: Setting in place automated systems for real-time data acquisition not only helps to collect more Hydro Met data, but also avoids the cost of losing data points that are required for analysis and modelling of both operations and investment planning. Benefits include the reduced uncertainties in estimation of parameters needed for project design (which result in either over-design or under-design) as well as postponing future development projects decisions in order to collect data.[8] These potential benefits can be partially captured by measuring reductions in the over-design of water infrastructure (refer below).

(ii) Better data can also improve the understanding of the impact of poor water quality on public health and justify the need for addressing the issue. This is difficult to measure directly as improved awareness is only one factor that could affect behavior change (e.g., to boil or filter water to avoid health risks of water-borne diseases) or policy action (e.g., to address water pollution) that would, in turn, reduce the risks of water-related morbidity and mortality.

(iii) Using maps and models to visualize problems, proposals and potential options also makes it easier to inform decision-makers, from bureaucrats to politicians at national, state and local levels. This is an intangible benefit, and most often heard from the participants of HPII.

(iv) Benefits of better information: Higher quality data collected under the NHP, as well as information generated through hydrological analysis, will also help the planning and design of new water infrastructure (e.g., dams, canals, and drinking water schemes), water-related projects (e.g., INR 500 billion Prime Minister's Krishi Sinchayee Yojana [PMKSY]), industrial development (individual units, industrial estates, Special Economic Zones , etc.), rail and metro networks, and urban infrastructure (for fast-growing small towns, Smart cities,

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[8]Hamilton, S. (2015), *The Value of Water Monitoring* [eBook], Vancouver: Aquatic Informatics, Table 1, p. 31. Available at http://aquaticinformatics.com/news/ebook-value-of-water-monitoring/

etc.). This is an important benefit and yet difficult to measure with a high degree of confidence.

(v) More accurate and reliable data and (technical) analysis to support the design and construction of water infrastructure, for project review and approval, and for water allocation will help to avoid unintended and costly consequences, including negative externalities. Reliable and trustworthy hydrological information can prevent the over-use, misuse or abuse of water resources, cases in point being over-abstraction of groundwater and water pollution. However, it is difficult to attribute this benefit directly to the NHP as there are many other factors involved in changing behavior (e.g., realizing these benefits depends on the actions of various central government Ministries – such as the Ministry of Rural Development and Ministry of Environment and Forests – and state government departments).

(vi) More reliable forecasts can help decision-making processes on activities ranging from household-level decisions on whether or not to carry umbrellas on a given date, decisions by farmers on what crops to plant and when, and when to carry out pesticide applications, and the design of crop insurance programs, to planning in sectors such as fisheries, transportation and shipping (including through inland waterways), recreation and tourism. Accurately measuring these impacts – though not impossible – is exceedingly difficult (and costly) because of attribution issues and the methodologies required.

(vii) Improved conflict resolution and coordination: Commonly agreed, publicly-shared and undisputable data sets can vastly reduce uncertainty and disputes in implementing inter-state agreements and treaties, and also improve inter-state coordination on water-related issues. Making these data publicly available also helps improve transparency both among government and civil society. This is an important intangible benefit.

(viii) Social and environmental benefits: There are potentially high social benefits to the poor – whether farmers, landless laborers, unskilled workers, slum dwellers, or other vulnerable sectors of society – from improved water availability through better management.[9]The project could also generate environmental benefits, e.g., conservation and preservation of river flora and fauna through improved river water flows, following better water management (which, in turn, could have aesthetic value and generate recreational benefits). These benefits – although potentially important – are not included in the BCA for the reasons described above.

Measurable but minor benefits

12. Some of the measurable but minor benefits include:

(i) Reduced time and staff cost of departmental consultancies: State groundwater agencies routinely carry out investigations of groundwater potential for clients that include farmers, institutions and industries.[10] These geo-physical surveys are consultancy services and are charged to the client. During HP-II, Tamil Nadu state purchased instruments (IGS Digital Terrameters) that provided immediate on-field results, which enabled a single geologist to complete in a day the work that would have otherwise taken two geologists three days to

[9] Social weights derived from indices such as the Atkinson's inequality index are generally used in benefit-cost analyses to accord a higher social value to benefits to the poor. This however requires the disaggregation of beneficiaries to identify the poor.

[10]Farmers wishing to take bank loans to drill new bore wells and to avail of government subsidies available for such bore wells are required to get a Clearance Certificate from the Ground Water Department (GWD). When farmers apply to the GWD, the concerned Executive Engineer (EE) and his staff carry out a hydro-geological reconnaissance survey to ascertain the availability of groundwater on the farmer's field and, if so, to identify potential sites for drilling.

complete. The total annual savings for the whole state from the improved instruments is around INR 6 million.[11] For just the 14 states covered under NHP that did not participate in HP-II, this represents an average saving of INR 84 million (USD 1.4 million) per year from similar upgradation of survey instruments.

(ii) Reduced time and staff cost of internal studies: State governments carry out feasibility studies for planned water infrastructure which could be conducted much more efficiently with DSSs and improved equipment. During HP-II, in Kerala, the state carried out around 20 studies over a period of two years, most of which would have taken the Water Resources Department (WRD) one year per study without the DSS and improved equipment. The staff cost savings alone would be around INR 2 million per study and around INR 20 million per year for 10 studies.[12] Under the same assumptions and with unchanged rates, the 14 new states of NHP would gain a total annual benefit of INR 280 million (USD 4.7 million) per year.

(iii) Avoided cost of duplicating water management software: The centralized procurement of software for water management (e.g., E-SWIS, E-GeMS, MikeBasin, and HEC) represents a saving for state governments, which may otherwise have purchased such software over the project period out of their own funds, as proposed under HP-II. From the proposals submitted by various states the average cost of software is around INR 10 million, which would give a total of INR 290 million for all 29 states, as against a one-time centralized procurement cost of INR 10 million. This represents a one-time saving of INR 280 million (USD 4.7 million), without including the incremental costs of staff to run these systems, the annual maintenance contracts (AMCs) for their upkeep or replacement costs (assuming a 10-year life-cycle of these software systems).

Measured Economic Benefits

13. This analysis captures two main potential benefits of the NHP, which are: (1) the benefits of reduced damages from flooding; and (2) the benefits of better (dynamic and modeling-based) reservoir management, i.e., 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 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 in order to change the planning, design and operations of water and other infrastructure projects. A case in point is the reservoir operation schedule (ROS) for each dam that has been in place from

[11] At an average salary of INR 40,000 per month, two staff members working for three days would cost INR 12,000 (@ INR 2000 per day, given a 20-day week), while one staff member working for a day is INR 2,000, giving a net gain of INR 10,000 per survey. The 10 state-wide units carried out an average of 5 surveys per month in 2014-15, totaling 600 surveys across the state in a year, representing a saving of INR 6 million. Personal communication: Mr. S.S. Raja, Assistant Executive Engineer and Mrs. Rajalakshmi, Chief Engineer (Groundwater), StateGround and Surface Water Management Agency, Government of Tamil Nadu, Chennai. 8 September 2015.

[12] The annual staff cost of one study done by two Assistant Engineers (full time @INR 50,000 per month), one Draughtsman (full time @ INR 25,000 per month), one Assistant Executive Engineer (one-third time @ INR 60,000 per month), one Executive Engineer (one-fifth time @ INR 75,000 per month) is INR 2.04 million, while it would costs only INR 40,000 when done by one AE in a month. The total annual saving is INR 2 million per study and INR 20million for 10 studies. Personal communication: Mr. B. Jayaram, retired Chief Engineer, WRD, and Mr. Thomas Mathew, Assistant Director, WRD, Government of Kerala, 8 September 2015.

commissioning and continues to be adhered to (as far as possible) with little analytical basis because of a fear 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.

14. The overall aim of the NHP is to create an accurate, reliable and thus credible Hydromet and decision-support systems, 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 on-going operations and planning processes at 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.

1. Reduced damages from flooding

15. Two key components of the Hydromet systems, i.e., real-time data acquisition systems (RTDAS) and real-time decision support systems (RTDSS), improve the 'organization, access and evaluation of Hydromet data and forecasting of snowmelt and runoff, as well as estimates of corresponding river flow'[13] which in turn could reduce flood damages. According to HP-II analysis, 72 hour rainfall forecasts from the RTDAS have an accuracy of 60 percent, 48 hour forecasts, 75 percent, and 24-hour forecasts, 90percent.[14] 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 happened, for instance, in Maharashtra in 2005-06 causing two out of the three flooding events).

16. 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 8-year implementation period (starting in Year 9), even though some states are likely to realize these benefits much sooner. The Bhakra-Beas Management Board (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[15]. 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)[16] 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: (1) the upper Ganga and upper Brahmaputra basins, where there are no control structures, and (2) other river basins, where there are control structures.

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[13] World Bank (2014) *Implementation Completion and Results Report (IBRD-47490)* of the Hydrology Project Phase II (HP-II), South Asia Region, India Country Management Unit, Global Water Practice, p. 52.

[14] Mr. Doiphode and Mr. Bagde, Executive Engineers, Water Resources Department, Government of Maharashtra, Personal communication, 24 August 2015.

[15] Mr. Shurushe, Chief Engineer, Water Resources Department, Government of Maharashtra, Personal communication, 24 August 2014; Mr. Anish Bansal, Danish Hydrology Institute consultant to BBMB, personal communication, 28 August 2015

[16] Nassim Nicholas Taleb (2010), *The Black Swan: The Impact of the Highly Improbable*, Random House and Penguin, 2nd ed.

1(A): Upper Ganga and Brahmaputra basins:

17. 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 paucity of adequately disaggregated data.[17] If included, these would likely increase the estimated benefits from avoided flood damage.

18. 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 people.[18] 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 per cent 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 per cent of lives will be saved by a 2-day forecast that is 75 per cent reliable is adopted here.[19]The statistical value of each life lost is calculated by adjusting the latest estimate of the United States Environment Protection Agency of approximately USD 6 million to India by assuming an income elasticity of 1.5.[20] The estimated 'Value of Statistical Life' (VSL) for India is approximately INR 0.552 crores (USD 92,000 assuming an exchange rate of INR 60 to 1 USD). The average annual benefit from improved flood forecasting in these five states is thus approximately INR 230 crores (Table 2).

States	Average no. of lives lost per year due to floods (1996-2012)	Proportion of lives assumed saved by better forecasting (%)	Assumed Value of Statistical Life (INR M)	Average annual benefit from lives saved (INR M)
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**			**2293.6**

Table 2: Incremental benefits of lives saved in the upper Ganga and Brahmaputra basins

[17]The current estimation uses only state-level data available with central agencies which does not detail basin and district-wise figures for human and livestock lives lost (only available at state and district levels), which are needed for accurate estimates. State-specific figures for livestock lost are also not available with central agencies. Also, while estimates of infrastructural damage are available, it is unclear how much of this damage could be avoided by reduced flooding: repeated flooding of streets and houses due to poor urban drainage can weaken building foundations and hence the actual collapse will be a cumulative impact, and not one directly attributable to one flooding event.

[18] Estimates of the Central Water Commission (CWC), 30 September 2015.

[19] Rogers, D., and Tsirkunov, V., (2010) *Costs and benefits of early warning systems.* [pdf] Washington: World Bank and ISDR. Available at http://www.preventionweb.net/english/hyogo/gar/2011/en/bgdocs/Rogers_&_Tsirkunov_2011.pdf; Sorensen and Mileti (1988).

[20] Hammitt, J. K., & Robinson, L. A. (2011) The income elasticity of the value per statistical life: transferring estimates between high and low income populations. *Journal of Benefit-Cost Analysis, 2*(01), 1-29. In general, the higher the income elasticity assumed, the lower the VSL. Hammit and Robinson (2011) note that the income elasticity is usually higher than 1 for developing countries, and hence, an assumed elasticity of 2 will underestimate the VSL.

1(B) Other river basins:

19. 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 above, only a proportion of the potential lives lost and damage to agriculture and infrastructure are assumed to be avoided due to NHP.

States	**Value of deaths avoided**				**Value of flood damage avoided**			Mean annual benefits (INR M)
	Mean no. of lives lost (1996-2012)	Percent lives saved	Value of statistical life (INR M)	Mean annual value of deaths avoided (INR M)	Mean annual value of other damage (INR M)	Percent damage avoided	Mean annual value of damage avoided (INR M)	
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**	**4,884.8**

Table 3: Incremental benefits of lives saved and infrastructure damage avoided (other basins)

20. The average number of human lives lost each year due to floods during the period 1996-2012 in the states of Andhra Pradesh, Karnataka, Orissa and West Bengal[21] is estimated from published official records to be 496 people.[22]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 above). As regards the reduction in damages, the BBMB reported zero damage due to floods after 2013, when the new DSS was installed,[23] while at least 50 percent of damage was caused by emergency releases from the Koyna dam in 2005-06[24] - which could then be prevented by the more accurate rainfall forecasts[25].Various studies have shown that forecast improvements can reduce average annual damages by a few percent percentage points to up to 35%.[26] A conservative estimate of a 5% reduction in damages – in line

[21] Note that the benefits from flood forecasting in Punjab and Maharashtra are not considered here as these have been used to estimate the benefits from HP-II, and the incremental benefit of NHP over HP-II is not likely to be considerable.
[22] Estimates of the Central Water Commission (CWC) from Mr. Manglik, Director, CWC.
[23] World Bank (2014), *Implementation Completion and Results Report (IBRD-47490)of the Hydrology Project Phase II*. New Delhi: World Bank, Global Water Practice, India Country Management Unit, South Asia Region, Table A4, p. 52.
[24] Pragmatix (2006) 'Addressing vulnerability to climate variability and climate change through an assessment of mitigation issues and options: Component 3: Maharashtra', report submitted to the World Bank, New Delhi: Pragmatix Research & Advisory Services Pvt Ltd., p. 76.
[25] Mr. Doiphode and Mr. Bagde, Executive Engineers, Water Resources Department, Government of Maharashtra, personal communication, 24 August 2015.
[26]Integrated Flood Forecasting, Warning and Response Systems (http://www.un.org/esa/sustdev/publications/flood_guidelines_sec03.pdf); Quantifying the Benefits of a Flood Warning System, 2004.

with recent analyses in the region – is adopted here.[27] Using the VSL for India (refer above) and estimated reductions in lives lost and damage to crops, buildings and public utilities, the annual benefits of improved flood forecasting in these states are estimated to be INR 488 crores (Table 3).[28]

2. Benefits of better reservoir management

21. 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).[29]This represents approximately 10 percent of total dam capacity.[30] 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.[31] Existing reservoirs in only half of the basins are assumed to benefit from better reservoir management by the end of the project period.[32] Note that it is also assumed that: (1) 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 (2) 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.

(2a) Improved hydropower generation

22. 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 currently unmet electricity demands.[33,34] The benefit is estimated by valuing the hydroelectricity generated by these 'additional' water releases.

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[27] World Bank (2012), 'Project Appraisal Document of the Pilot Program for Climate Resilience of the Strategic Climate Fund to Nepal for Building Resilience to Climate-related Hazards. Washington DC: World Bank, p. 108.

[28] Very few studies have attempted to disaggregate types of damage within broader categories (e.g., personal losses, business losses, agricultural land, buildings, other infrastructure, etc.). For one study that does so, see Fiji Technical Report: An economic evaluation of flood warning in Navua, Fiji (EU–SOPAC, 2008).

[29] DHI (2013) Report on Applications of the Decision Support Systems for Planning for HP-II, New Delhi: Danish Hydrology Institute.

[30] Mr. Bagde, Executive Engineer, Water Resources Department, Government of Maharashtra, Personal communication. 24 August 2015; Mr. Doiphode, Executive Engineer, Water Resources Department, Government of Maharashtra,. Personal communication. 3 September 2015.

[31] Expert opinion from state-level engineers during the planning workshop of the NHP, New Delhi, 3 – 11 Sep 2015.

[32] Calculated as half of the total average annual hydropower generated in each basin.

[33]In the case of the Koyna dam in Maharashtra, there is a daily limit of hydropower generation (67.5 mWh) which cannot be exceeded even if additional water releases can be made. Mr. Doiphode, Executive Engineer, Water Resources Department, Government of Maharashtra, Personal communication. 24 August 2015.

[34] 'India is still home to about 350 million people who lack access to electricity, more than 25 percent of the worldwide total of 1.4 billion people without electricity. The per capita electricity consumption (kWh per capita) is only around 566 compared to world average of 2,782. India aims to achieve universal access and an annual minimum consumption of 1,000 kWh for all its citizens by 2012. India also faces massive demand-supply gap exacerbated by delays in capacity addition, problems in securing fuel linkages and inefficiencies especially in network segments. ... Lack of reliable power continues to be a major constraint to sustained

23. The additional 0.5 percent of reservoir capacity released will generate an incremental 0.5 percent of hydropower. The table below shows average hydropower generation calculated over three years (2011-14) by state.[35]The shadow price of hydropower is taken to be INR 3.00 per kWh,[36]and thus, the average annual incremental benefit from the increase in hydropower generation is approximately INR 2,476 million (USD 41.3 million) (Table 4). (For the BCA, increased hydropower generation is assumed to begin in Year 9.)

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 M)
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	**1,69,343**		**846.5**	**2,476.0**

Table 4: Incremental benefits of hydropower generation

(2B) Enhanced canal water for irrigation

24. 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 *oorani*s, 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.

25. 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

industrial growth, investment and economic competitiveness for the country. Electricity shortages are estimated to cost the country around 7 percent of GDP. Electricity generation/supply has grown at only an average of 5.3 percent per year. Improved performance of the sector is necessary for ensuring sustained and inclusive growth.' World Bank (2015) India's Power Sector [online] Available at http://www.worldbank.org/en/news/feature/2010/04/19/india-power-sector.

[35] From www.Indiastat.com quoting the reply to Lok Sabha unstarred question number 1113 dated 17 July 2014.

[36] This is the conservative estimate of the opportunity cost of power derived and used in World Bank (2010) India-Andhra Pradesh Water Sector Improvement Project, Project Appraisal Document, New Delhi: World Bank.

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.[37] The shadow price is taken to be INR 0.60 per KL.[38] Accordingly, the average annual benefit from the additional water released from reservoirs for agriculture is estimated to be approximately INR 155 million (USD 2.6 million) (Table 5).

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 M)**
Andhra Pradesh	10.0	0.50	80	40.1	24.1
Chhattisgarh	1.9	0.50	80	7.6	4.6
Gujarat	5.5	0.50	80	21.8	13.1
Himachal	3.1	0.50	80	12.5	7.5
Jharkhand	0.2	0.50	80	0.9	0.6
Karnataka	8.0	0.50	80	31.9	19.2
Kerala	1.6	0.50	80	6.2	3.7
Madhya Pradesh	13.4	0.50	80	53.7	32.3
Maharashtra	4.0	0.50	80	16.0	9.6
Orissa	5.9	0.50	80	23.5	14.1
Punjab	1.2	0.50	80	4.7	2.8
Rajasthan	1.6	0.50	80	6.6	4.0
Tamil Nadu	2.1	0.50	80	8.5	5.1
Uttar Pradesh	3.2	0.50	80	12.7	7.7
Uttarakhand	2.4	0.50	80	9.6	5.8
West Bengal	0.7	0.50	80	2.8	1.7
TOTAL					**155.4**

Table 5: Incremental benefits from canal water releases for irrigation

(2C) Improved drinking water supply

26. 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 (e.g., check dams, bore wells, pipelines).[39] 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,

[37]Although current water usage pattern is that around 90% is used by irrigation, Amarasinghe et a., (2007) have suggested that by 2025 the proportion used by irrigation will reduce and more water will be used by industry (see Amarasinghe, U.A., Shah, T., Turral, H and Anand, B.K. (2007). India's water future 2025-2050: business-as-usual scenario and deviations, IWMI Research Report 123, Colombo: International Water Management Institute).

[38]Jabeen, S., Ashfaq, M., & Ahmad-Baig, I. (2006). Linear program modelling for determining the value of irrigation water. *J. Agric. Soc. Sci*, *2*(2), 101-105. According to this study of the shadow price of irrigation water in water-deficient months in Pakistani agriculture, the shadow price of water ranged from Rs. 0.45 to Rs. 1.31 for small farms; from Rs. 0.86 to Rs. 1.64 for medium farms; from Rs. 0.95 to Rs. 1.84 for large farms. Using the number of small, medium and large farms from the Indian agricultural census, the weighted average was calculated.

[39]For example, Kerala spent INR 550million for emergency water supplies in 2013, while other southern states spend around INR 3,000-4,000 million per year.[39]Since the scarcity forces states to spend in order to (a) make additional water available and then (b) supply this water to consumers through tankers, the additional surface water from improved reservoir operations can save both these costs.

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) amongst many others.[40]

27. 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 on 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),[41] additional drinking water supplies are estimated to be approximately 26 MCM per annum (Table 6). 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) in Maharashtra[42] to INR 1 per liter in Kerala,[43] 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 (USD 216 million) (Table 6).

State	**Total Reservoir capacity (BCM) of half the basins**	**Percentage increase in capacity**	**Proportion used for drinking**	**Additional drinking water (MCM)**	**Annual incremental benefit (INR M)**
Andhra Pradesh	10.0	0.50	0.08	4.0	2,004.4
Chhattisgarh	1.9	0.50	0.08	0.8	381.3
Gujarat	5.5	0.50	0.08	2.2	1,090.8
Himachal	3.1	0.50	0.08	1.2	622.9
Jharkhand	0.2	0.50	0.08	0.1	47.1
Karnataka	8.0	0.50	0.08	3.2	1,594.6
Kerala	1.6	0.50	0.08	0.6	309.8
Madhya Pradesh	13.4	0.50	0.08	5.4	2,686.2
Maharashtra	4.0	0.50	0.08	1.6	799.7
Orissa	5.9	0.50	0.08	2.4	1,175.9
Punjab	1.2	0.50	0.08	0.5	234.4
Rajasthan	1.6	0.50	0.08	0.7	327.9
Tamil Nadu	2.1	0.50	0.08	0.8	422.9
Uttar Pradesh	3.2	0.50	0.08	1.3	635.6
Uttarakhand	2.4	0.50	0.08	1.0	481.1
West Bengal	0.7	0.50	0.08	0.3	139.4
TOTAL				**25.9**	**12,954.0**

Table 6: Incremental benefits of additional drinking water supplied

(2D) Improved Industrial Water Supply

28. 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

[40] The benefits of additional drinking water include the avoided economic costs of morbidity and mortality (which range from costs of medical treatment, productivity losses to costs of storage, filtration and treatment of water), purchasing bottled water, and of carrying water home over long distances. See WSP (2011) *Economic Impacts of Inadequate sanitation in India*, [pdf] Washington D.C.: Water and Sanitation Program (with Asian Development Bank, Australian Aid and UK Department for International Development. Available at http://www.wsp.org/sites/wsp.org/files/publications/WSP-esi-india.pdf

[41] Amarasinghe, U.A., Shah, T., Turral, H and Anand, B.K. (2007). *op.cit.*

[42] Mr. Doiphode, Executive Engineer, Water Resources Department, Government of Maharashtra, Pune. Personal communication, 25 August 2015.

[43] Mr. G. Sreekumaran, Chief Engineer (South), Kerala Water Authority. Personal communication, 9 September 2015.

productivity, which is a national priority. Based on the projected water utilization pattern for 2025,[44] 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,[45]the average annual benefits from the incremental water supplied for industrial purposes is approximately INR 280 million (USD 4.6 million) (Table 7).

State	Total reservoir capacity (BCM) of half the basins	Percentage increase in reservoir capacity (%)	Proportion available for industrial use (%)	Additional water available for industrial use (MCM)	Annual incremental benefit (INR M)
Andhra Pradesh	10.0	0.50	12.00	6.0	43.3
Chhattisgarh	1.9	0.50	12.00	1.1	8.3
Gujarat	5.5	0.50	12.00	3.3	23.6
Himachal	3.1	0.50	12.00	1.9	13.5
Jharkhand	0.2	0.50	12.00	0.1	1.0
Karnataka	8.0	0.50	12.00	4.8	34.5
Kerala	1.6	0.50	12.00	0.9	6.7
Madhya Pradesh	13.4	0.50	12.00	8.1	58.0
Maharashtra	4.0	0.50	12.00	2.4	17.3
Orissa	5.9	0.50	12.00	3.5	25.4
Punjab	1.2	0.50	12.00	0.7	5.1
Rajasthan	1.6	0.50	12.00	1.0	7.1
Tamil Nadu	2.1	0.50	12.00	1.3	9.2
Uttar Pradesh	3.2	0.50	12.00	1.9	13.8
Uttarakhand	2.4	0.50	12.00	1.4	10.4
West Bengal	0.7	0.50	12.00	0.4	3.0
TOTAL					**279.8**

Table 7: Incremental benefits of water supplied for industrial production

Costs

29. The full project cost of INR 21 billion is taken, which includes contributions from the Government of India and state governments. This includes all setting up and operations costs of all four project components, i.e., instrumentation and data collection; data analysis and information generation; development of DSSs 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, all the systems set up during the project are assumed to be operated and maintained by existing government staff and costed accordingly.

30. It is assumed that 5 percent of project costs are spent in each of the first 2 years, and 15 percent in each of the subsequent 6 years. Annual maintenance charges (AMCs) for all the hardware systems purchased are included in the total project cost until Year 8. From Year 9, these are taken to be 10 percent of Component A costs. It is further assumed that the Hydromet systems installed as part of Component A have a life of 10 years, and so these are replaced in Years 10 and 20. This will over-estimate costs since equipment bought in Year 8 of the project will not have to be replaced in Year 10.

Results

31. The additional assumptions for the economic benefit cost analysis (BCA) are the following:

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[44] Amarasinghe, U. A., Shah, T., & Anand, B. K. (2007) *op.cit*.

[45]3iNetwork (Inde) (2011) *India Infrastructure Report 2011: Water: Policy and Performance for Sustainable Development*. New Delhi: Oxford University Press. Quoting Kumar, S., (2006) 'Analyzing industrial water demand in India: an output-distance function approach' *Water Policy*, volume 8, pp 15-29.

- All benefits are assumed to occur once NHP is fully implemented, i.e., starting in Year 9 (so after the 8-year project period), even though some states are likely to realize these benefits even sooner.
- Costs are incurred as above.
- The time period for the analysis is 25-years
- The discount rates are 12 percent and 10 percent

The economic analysis shows that the NPV is INR 50 billion (USD 834 million) (at a discount rate of 12 percent) and INR 68 billion (USD 1,132 million) (at a discount rate of 10 percent). The economic IRR is 34.8 percent.

Sensitivity Analysis

32. A sensitivity analysis has been carried out for three scenarios: (1) Costs increase by 20 percent; (2) Benefits reduce by 20 percent and (3) Costs increase by 20 percent and benefits reduce by 20 percent. The analysis shows that even the third scenario has an IRR of 27 percent (Table 10).

	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%

Table 10: Sensitivity analysis of BCA findings

Financial Analysis

33. Hydromet services are effectively 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) **<u>Savings in government expenditure on disaster relief and rehabilitation:</u>** 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.[46] If only 5 percent of these requests were avoided, this would represent more than two-third of project costs in one year alone.

(ii) **<u>Reduced water infrastructure construction costs:</u>** 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)

[46]Source :Lok Sabha Unstarred Question No.877 dated 28.11.2006, Indiastat website.

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).[47] 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.

[47]The major objective of the PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation (HarKhetkopani), improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal based water for peri-urban agriculture and attract greater private investment in precision irrigation system. The scheme also aims at bringing concerned Ministries/Departments/Agencies/Research and Financial Institutions engaged in creation/use/recycling/potential recycling of water, brought under a common platform, so that a comprehensive and holistic view of the entire "water cycle" is taken into account and proper water budgeting is done for all sectors namely, household, agriculture and industries.' PIB (2015) 'Pradhan ManthriKrishiSinchayeeYojana (PMKSY)' [online] New Delhi: Press Information Bureau, Cabinet Committee on Economic Affairs. Available at http://pib.nic.in/newsite/PrintRelease.aspx?relid=122935