**Document of**
**The World Bank**

Report No: ICR00002931

IMPLEMENTATION COMPLETION AND RESULTS REPORT
(IBRD-47490)

ON A

LOAN

IN THE AMOUNT OF US$104.98 MILLION

TO THE

REPUBLIC OF INDIA

FOR A

HYDROLOGY PROJECT PHASE II

(HP-II)

December 15, 2014

Global Water Practice
India Country Management Unit
South Asia Region

CURRENCY EQUIVALENTS

Currency Unit = Indian Rupee (INR)

At Appraisal Rs. 1 = US$0.0222, US$1 = Rs. 45

At Completion Rs.1 = US$0.0166, US$1 = Rs. 60.12

FISCAL YEAR: April 1- March 31

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ADCP | Acoustic Doppler Current Profiler |
| AIMS | Aquifer Information and Management System |
| AMC | Annual Maintenance Contract |
| AQC | Analytical Quality Control (for laboratories) |
| ARG | Automatic Rain Gauges |
| AWS | Automatic Weather Station |
| BBMB | Bhakra-Beas Management Board |
| CAS | Country Assistance Strategy |
| CPS | Country Partnership Strategy |
| CGWB | Central Ground Water Board |
| CPCB | Central Pollution Control Board |
| CWAS | Corporate Water Sector Strategy (World Bank) |
| CWC | Central Water Commission |
| CWPRS | Central Water and Power Research Station |
| DEA | Department of Economic Affairs |
| DFID | Department for International Development (UK) |
| DSS | Decision Support System |
| DSS-P | Decision Support System for Planning |
| DWLR | Digital Water Level Recorder |
| eGEMS | Ground Water Estimation and Management System (web-based) |
| EIRR | Economic Internal Rate of Return |
| EFC | Expenditure Finance Committee |
| eWQIS | Water Quality Information System (web-based) |
| FMR | Financial Management Report |
| FY | Fiscal Year |
| FYP | Five Year Plan |
| GIS | Geographical Information System |
| GoI | Government of India |
| GPRS | General Packet Radio System |
| GSM | Global System for Mobile communication |
| GW | Ground Water |
| GWIS | Ground Water Information System |
| HDA | Hydrological Design Aids |
| HDUG | Hydrological Data User Groups |
| HIN | Hydrological Information Needs (document) |
| HIS | Hydrological Information System |
| HISMG | Hydrological Information System Management Groups |
| HP-I | Hydrology Project (completed in Dec. 2003) |
| HP- II | Hydrology Project Phase II |
| IA | Implementing Agency |
| ICRR | Implementation Completion and Results Report |
| IMD | India Meteorological Department |
| IP | Implementation Progress |
| ISR | Implementation Status and Results |
| ISRO | Indian Space Research Organization |
| IWRM | Integrated Water Resources Management |
| M&E/L | Monitoring & Evaluation/Learning |
| MIS | Management Information System |
| MoU | Memorandum of Understanding |
| MoWR, RD&GR | Ministry of Water Resources, River Development and Ganga Rejuvenation |
| MTR | Mid-Term Review |
| NAQUIM | National Aquifer Mapping program |
| NGO | Non-governmental organization |
| NGRI | National Geophysical Research Institute, Hyderabad |
| NIH | National Institute of Hydrology |
| NWIC | National Water Informatics Center |
| NWP | National Water Policy |
| NWA | National Water Academy |
| O&M | Operation and Maintenance |
| PAD | Project Appraisal Document |
| PCS | Project Coordinating Secretariat |
| PDO | Project Development Objective |
| PDS | Purpose Driven Study |
| PIP | Project Implementation Plan |
| QER | Quality at Entry Review |
| QPF | Quantitative Precipitation Forecasting |
| RASA | Regional Aquifer System Analysis (USGS) |
| ROS | Reservoir Operation System |
| RTDAS | Real-time Data Acquisition System |
| RTDSS | Real-time Decision Support System |
| RTSF | Real-time Stream flow Forecasting |
| RTWQM | Real-time Water Quality Management/Monitoring |
| SAPR | Semi-Annual Progress Report |
| SPCB | State Pollution Control Board |
| SW | Surface Water |
| SWIS | SW Information System |
| TA | Technical Assistance |
| TAMC | Technical Assistance and Management Consultancy |
| TEM | Transient Electro-Magnetic |
| TOR | Term of Reference |
| T-o-T | Training of Trainers |
| WPP | Water Partnership Program |
| WRICB | Water Resources Institutions and Capacity Building |
| WRIS | Water Resources Information System |
| WRMA | Water Resources Monitoring Applications |
| WRMS | Water Resources Monitoring System |

| | |
|---|---|
| Vice President: | Annette Dixon |
| Country Director: | Onno Ruhl |
| Project Manager: | William Kingdom |
| Project Team Leader: | Anju Gaur |
| ICR Team Leader: | Johannes Geert Grijsen |

**REPUBLIC OF INDIA**

**HYDROLOGY PROJECT PHASE II**

**CONTENTS**

| A. Basic Information | | | |
|---|---|---|---|
| Country: | India | Project Name: | Hydrology Project Phase II |
| Project ID: | P084632 | L/C/TF Number(s): | IBRD-47490 |
| ICR Date: | 12/15/2014 | ICR Type: | Core ICR |
| Lending Instrument: | SIL | Borrower: | Department of Economic Affairs, Ministry of Finance |
| Original Total Commitment: | US$104.98M | Disbursed Amount: | US$91.58M |
| Revised Amount: | US$104.98M | | |
| **Environmental Category: C** | | | |
| **Implementing Agencies:** | | | |
| **Co-financiers and Other External Partners:** | | | |

| B. Key Dates | | | | |
|---|---|---|---|---|
| **Process** | **Date** | **Process** | **Original Date** | **Revised / Actual Date(s)** |
| Concept Review: | 08/18/2003 | Effectiveness: | 04/05/2006 | 04/05/2006 |
| Appraisal: | 04/12/2004 | Restructuring(s): | | 11/13/2009<br>03/25/2012<br>02/14/2014 |
| Approval: | 08/24/2004 | Mid-term Review: | | 10/01/2009 |
| | | Closing: | 06/30/2012[1] | 05/31/2014 |

| C. Ratings Summary | |
|---|---|
| **C.1 Performance Rating by ICR** | |
| Outcomes: | Moderately Satisfactory |
| Risk to Development Outcome: | Negligible to Low |
| Bank Performance: | Moderately Satisfactory |
| Borrower Performance: | Moderately Satisfactory |

| C.2 Detailed Ratings of Bank and Borrower Performance (by ICR) | | | |
|---|---|---|---|
| **Bank** | **Ratings** | **Borrower** | **Ratings** |
| Quality at Entry: | Moderately Satisfactory | Government: | Moderately Satisfactory |
| Quality of Supervision: | Moderately Satisfactory | Implementing Agency/Agencies: | Moderately Satisfactory |
| **Overall Bank Performance:** | Moderately Satisfactory | **Overall Borrower Performance:** | Moderately Satisfactory |

[1] After delayed effectiveness closing data was changed from 08/31/2010 in PAD to 06/30/2012.

| C.3 Quality at Entry and Implementation Performance Indicators | | | |
|---|---|---|---|
| **Implementation Performance** | **Indicators** | **QAG Assessments (if any)** | **Rating** |
| Potential Problem Project at any time (Yes/No): | Yes | Quality at Entry (QEA): | None |
| Problem Project at any time (Yes/No): | Yes | Quality of Supervision (QSA): | None |
| DO rating before Closing/Inactive status: | Moderately Satisfactory | | |

| D. Sector and Theme Codes | | |
|---|---|---|
| | **Original** | **Actual** |
| **Sector Code (as % of total Bank financing)** | | |
| Central government administration | 15 | 10 |
| General water, sanitation and flood protection sector | 20 | 35 |
| Irrigation and drainage | 35 | 30 |
| Sub-national government administration | 25 | 20 |
| Water supply | 5 | 5 |

| | | |
|---|---|---|
| **Theme Code (as % of total Bank financing)** | | |
| Water resource management | 100 | 100 |

| E. Bank Staff | | |
|---|---|---|
| **Positions** | **At ICR** | **At Approval** |
| Vice President: | Annette Dixon | Praful C. Patel |
| Country Director: | Onno Ruhl | Michael F. Carter |
| Practice Manager: | William Kingdom | Constance A. Bernard/ Gajanand Pathmanathan |
| Project Team Leader: | Anju Gaur | E. V. Jagannathan |
| ICR Team Leader: | Johannes Geert Grijsen | |
| ICR Primary Author: | Johannes Geert Grijsen | |

## F. Results Framework Analysis

**Project Development Objectives (from Project Appraisal Document)**

The Project Development Objective (PDO) is to extend and promote the sustained and effective use of the Hydrological Information System (HIS) by all potential users concerned with water resources planning and management, both public and private, thereby contributing to improved productivity and cost-effectiveness of water related investments in 13 states and 8 central agencies. The framework of outcome and output indicators is outlined below.

**Revised Project Development Objectives (as approved by original approving authority): N/A**

**(a) PDO Indicator(s)**

| Indicator | Baseline Value | Original Target Values (from PAD) | Formally Revised Target Values | Actual Value Achieved at Completion |
|---|---|---|---|---|
| **PDO Indicator:** | **HIS mainstreamed by 90% of Implementation Agencies (IA) and consistently used by them as well as by Hydrologic Data User Group (HDUG) members and individuals to meet their planning and design requirements.** | | | |
| Value (quantitative or Qualitative) | 10%; HIS established in HP-I agencies, but not yet mainstreamed. | 90% | Not revised | 100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Target exceeded. An additional 11 states have introduced real-time hydro-meteorological systems to enable improved planning and operation. All IAs are using innovative HIS and GoI is keen on extending similar system in remaining river basins. | | | |

**b) Intermediate Outcome Indicator(s)**

| Indicator | Baseline Value | Original Target Values (from PAD) | Formally Revised Target Values | Actual Value Achieved at Completion |
|---|---|---|---|---|
| **Component 1: Institutional Strengthening** | **Agencies have the necessary capacity to use and promote the broad use of HIS among private and public sector users, and to develop proactive response systems for HDUG needs.** | | | |
| Value (quantitative or Qualitative) | 70% in the 9 HP-I states; no capacity in the 4 new States | 90% | Not revised | 100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | 100% achieved. Real-time monitoring and dissemination introduced to much larger scale than originally planned. Web-based data management is introduced (not yet completed) and new data dissemination policy is implemented through web-based India-Water Resources Information System (WRIS). | | | |

| Indicator | Baseline Value | Original Target Values (from PAD) | Formally Revised Target Values | Actual Value Achieved at Completion |
|---|---|---|---|---|
| **Indicator 1** | **IAs strengthened with requisite trained staff in place.** | | | |
| Value (quantitative or Qualitative) | 70% in the 9 HP-I states; no capacity in the 4 new states | 90% | Not revised | 100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | 100% achieved. Technical, operational and management training delivered to all IAs. HIS teams established in all IAs. Most agencies reported availability of in-house trainers and regular approval of annual training programs and budgets. | | | |
| **Indicator 2** | **HIS fully equipped, operational, functioning effectively and provided with adequate O&M funds.** | | | |
| Value (quantitative or Qualitative) | 70% in the 9 HP-I States; no capacity in the 4 new States | 90% | Not revised | 100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Achieved above target. HIS fully equipped with real-time and automated setup on larger scale than originally planned; web-based data management introduced and data dissemination expanded through India-WRIS; adequate O&M provided | | | |
| **Indicator 3:** | **Proactive HDUGs representing water resources stakeholders are in place.** | | | |
| Value (quantitative or Qualitative) | 70% in the 9 HP-I states; no capacity in the 4 new states | 90% | Not revised | 90% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments | Target achieved. Regular HDUG meetings and data dissemination through websites. | | | |
| **Component 2: Vertical Extension** | **All concerned agencies and users are adopting Hydrological Design Aids (HDA) and Decision Support Systems (DSSs) for water resources planning and management activities, and Purpose Driven Studies (PDS) have contributed to knowledge advances in India's water sector.** | | | |
| Value (quantitative or Qualitative) | Very little practice (0%) | 80% | Not revised | 75-150% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Target exceeded for establishment of real-time DSS for flood forecasting and reservoir management system and ground water aquifer mapping; DSS are used for planning investments; 38 PDS studies completed; HDA is 70% complete. | | | |
| **Indicator 1:** | **50% of targeted HDAs developed in the IAs have been incorporated into standard practice.** | | | |
| Value (quantitative or Qualitative) | Very little practice (0%) | 50% | Not revised | 0% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Partially achieved. Development of HDAs for water resources availability and yield assessment, flood estimates and reservoir sedimentation is partially completed (75%). Some training have been conducted, but the roll-out is yet to be initiated. | | | |

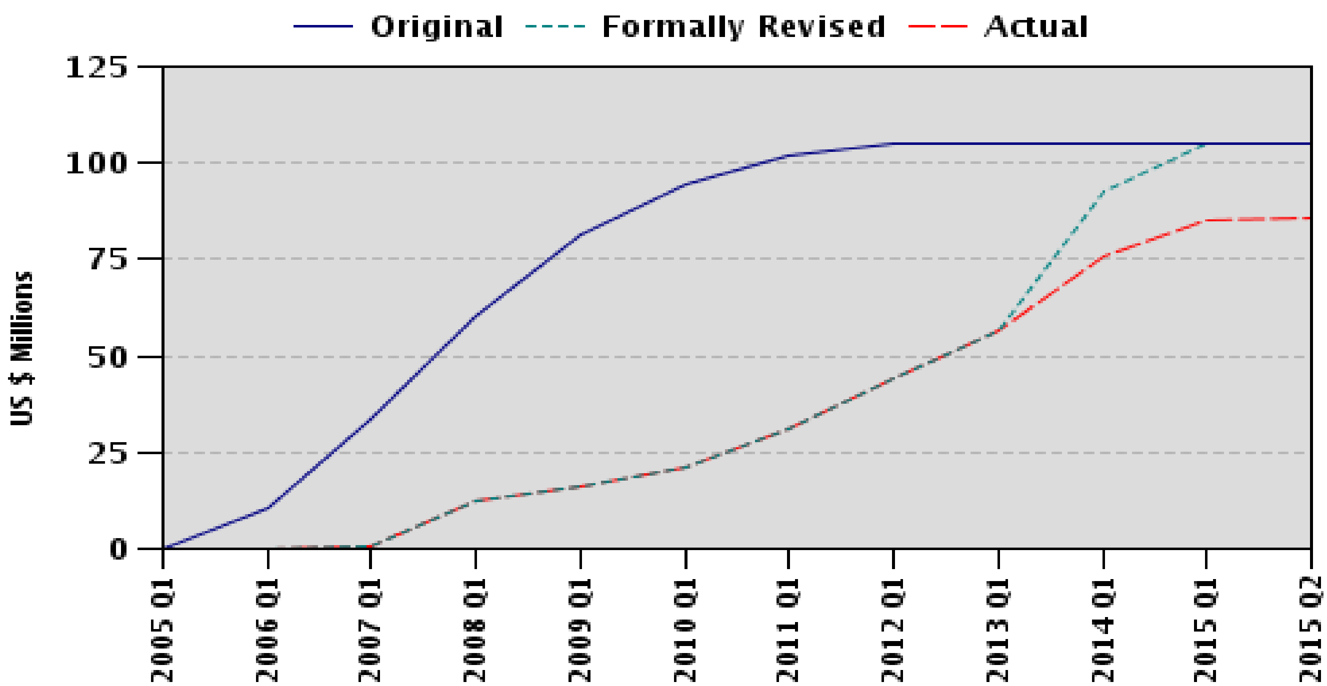
| Indicator | Baseline Value | Original Target Values (from PAD) | Formally Revised Target Values | Actual Value Achieved at Completion |
|---|---|---|---|---|
| **Indicator 2:** | **In 75% of agencies where DSSs have been successfully piloted, [these] are being replicated through in-house expertise.** | | | |
| Value (quantitative or Qualitative) | Very little practice (0%) | 75% | Not revised | 75-100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Substantially achieved. Real-time DSS systems established in 3 basins against target of 2 (150%); DSS-Planning systems completed for 11 basins in 9 HP-I States (75%); replication initiated in 4 States (45%) through in house expertise | | | |
| **Indicator 3:** | **At least 10 different types of private sector entities in each state are using HIS data and design aids.** | | | |
| Value (quantitative or Qualitative) | Very little practice | >10 | Not revised | >10 |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Substantially achieved. HIS data have been provided to a large spectrum of users through the website including municipal corporations, water supply agencies, industries, farmers, consultants, non-governmental organizations (NGOs) and research institutes; primarily acquired for hydraulic design purposes | | | |
| **Component 3: Horizontal Extension** | **HIS established in four new states and two new central agencies, and transparent and easy access for all users provided.** | | | |
| Value (quantitative or Qualitative) | No capacity in new IAs (0%). | 80% | Not revised | 100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | Targets substantially achieved, except for completion of State Data Centre building in Punjab (SDC is operational); Punjab Government has committed funds for its completion; Himachal Pradesh and Goa were strong performers. | | | |
| **Indicator 1:** | **80% of new HP agencies is equipped with a fully functional HIS (operational measurement sites/water quality labs and data processing/storage centers etc.)** | | | |
| Value (quantitative or Qualitative) | No capacity in new IAs (0%). | 80% | Not revised | 100% |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | 100% Achieved. New monitoring networks are established above targets and State Data Centers (SDC) is operational. Punjab Government has committed funds for completion of its new SDC building. Himachal Pradesh and Goa were strong performers. | | | |
| **Indicator 2:** | **At least 10 different types of private sector entities in each state are using HIS data and design aids.** | | | |
| Value (quantitative or Qualitative) | 0 | >10 | Not revised | >10 |
| Date achieved | 04/05/2006 | 06/30/2012 | 06/30/2012 | 05/31/2014 |
| Comments (incl. % achievement) | 100% Achieved. HIS data are regularly used by private entities in each state, including universities, NGOs and infrastructure developers. | | | |

| G. Ratings of Project Performance in ISRs | | | | |
|---|---|---|---|---|
| **No.** | **Date ISR Archived** | **DO** | **IP** | **Actual Disbursements (US$ millions)** |
| 1 | 12/29/2004 | Satisfactory | Satisfactory | 0.00 |
| 2 | 06/24/2005 | Unsatisfactory | Unsatisfactory | 0.00 |
| 3 | 12/14/2005 | Unsatisfactory | Unsatisfactory | 0.00 |
| 4 | 02/23/2006 | Unsatisfactory | Unsatisfactory | 0.00 |
| 5 | 06/21/2006 | Satisfactory | Moderately Satisfactory | 0.52 |
| 6 | 12/19/2006 | Satisfactory | Moderately Satisfactory | 10.53 |
| 7 | 06/18/2007 | Satisfactory | Moderately Satisfactory | 11.81 |
| 8 | 10/04/2007 | Satisfactory | Moderately Unsatisfactory | 12.70 |
| 9 | 04/12/2008 | Moderately Unsatisfactory | Unsatisfactory | 13.79 |
| 10 | 11/08/2008 | Unsatisfactory | Unsatisfactory | 16.74 |
| 11 | 05/08/2009 | Moderately Unsatisfactory | Unsatisfactory | 17.79 |
| 12 | 11/25/2009 | Moderately Satisfactory | Moderately Satisfactory | 21.60 |
| 13 | 05/21/2010 | Moderately Satisfactory | Moderately Satisfactory | 25.99 |
| 14 | 12/05/2010 | Moderately Satisfactory | Moderately Satisfactory | 32.46 |
| 15 | 03/26/2011 | Moderately Satisfactory | Moderately Unsatisfactory | 35.42 |
| 16 | 12/03/2011 | Moderately Satisfactory | Moderately Unsatisfactory | 46.30 |
| 17 | 03/11/2012 | Moderately Satisfactory | Moderately Satisfactory | 47.69 |
| 18 | 10/03/2012 | Moderately Satisfactory | Moderately Satisfactory | 57.92 |
| 19 | 12/10/2012 | Moderately Satisfactory | Moderately Satisfactory | 60.66 |
| 20 | 06/08/2013 | Moderately Satisfactory | Moderately Satisfactory | 72.46 |
| 21 | 12/09/2013 | Moderately Satisfactory | Moderately Satisfactory | 77.49 |
| 22 | 05/27/2014 | Moderately Satisfactory | Moderately Satisfactory | 78.47 |

| H. Restructuring (if any) | | | | | |
|---|---|---|---|---|---|
| **Restructuring Date** | **Board Approved PDO Change** | **ISR Ratings at Restructuring** | | **Amount Disbursed at Restructuring in USD millions** | **Reason for Restructuring & Key Changes Made** |
| | | **DO** | **IP** | | |
| 11/13/2009 | N/A | MS | MS | 21.55 | The disbursement percentages for various categories in the disbursement table of the LA were revised, as well as the dates of some provisions therein, without affecting the total cost of the project. |
| 03/25/2012 | N/A | MS | MS | 47.69 | Extension of closing date from June 30, 2012 to May 31, 2014 to enable the IAs to complete those activities already started and committed and to focus on providing technical support to |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | ensure long-term sustainability of project outputs in the 13 states and 8 central agencies. |
| 02/14/2014 | N/A | MS | MS | 78.47 | Expenditures of categories in the LA were reallocated in accordance with the actual work plan and progress, without affecting the total cost of the project. The reallocation mainly concerned the increase in operating and consultancy cost and the simultaneous decrease in other categories. |

## I. Disbursement Profile



## 1. Project Context, Development Objectives and Design

### 1.1 Context at Appraisal

1. **Country and sector issues:** India has varied climate and water resources. The availability of fresh water, both spatially and temporally, has become a major factor constraining the ability of the country's water supply, industrial and agricultural sub-sectors to meet the diversified needs of a growing population. Specific challenges facing the water sector include *inter alia*: i) the need to double food grain production by 2050, which precipitates increased water demands for irrigation while water demands for other sectors are also on the rise; ii) increased incidents of flooding attributed to intense rainfall; iii) progressive deterioration of water quality in surface water bodies and increased demands for maintaining ecological flows in rivers; iv) issues of salinity ingress in coastal areas, siltation of rivers and reservoir sedimentation; v) the need to use water efficiently for sustainable management; and vi) the need to prepare for the perceived adverse impacts of climate change. Meanwhile, a paradigm shift is ongoing from relatively isolated water resources developments towards comprehensive planning, development and management of water resources in a river basin context.

2. At the time of appraisal (April 2004), the Hydrological Information System (HIS[2]) developed under the first Hydrology Project (HP-I; 1996-2003), covering nine states and six central agencies,[3] was seen as an essential prerequisite for sound water resources planning and management. The HIS provided scientifically-verified, uniformly-acceptable and widely-accessible hydrological records covering all aspects of the hydrological cycle. The standardized HIS procedures and agreed inter-agency protocols (for data collection, collation, processing and exchange, and data sharing) had created a sound basis among all the implementing agencies (IAs) for moving towards improved planning and design of water resources development and long-term integrated water resource management (IWRM). However, notwithstanding the improvements made under HP-I, the HIS suffered the following deficiencies: (i) the insular culture that underpins data ownership and information sharing in India; (ii) inadequate geographic coverage of the database; (iii) restricted use of modern analytical tools; and (iv) lack of skilled manpower for hydrologic modeling and data analysis. One of the key requirements for comprehensive water resources planning is a sound hydrological database for use in modern planning and design tools. An inadequate and unreliable hydrological database, associated with a lack of data processing and modeling capabilities at (particularly state) agency level, was seen as a significant constraint in realizing optimal designs and operations of projects in the water sector. Therefore, the follow-on Hydrology Project Phase II (HP-II) was designed to continue supporting the enhancement of a comprehensive HIS in India, expanding its coverage to four more states and two more central agencies[4], improving access and use by the private sector and civil society, and consolidating and

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[2] HIS is an integrated water information system providing reliable, comprehensive and timely hydrological and meteorological data. It consists of: scientific hydrological and meteorological observation networks for both surface and ground water data (quantity and quality); data processing and data storage facilities; reliable data communication arrangements; and trained manpower for HIS operations and user support.

[3] HP-I states: Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha and Tamil Nadu. HP-I central agencies: Central Water Commission (CWC), Central Ground Water Board (CGWB), Central Water and Power Research Station (CWPRS), India Meteorological Department (IMD), Project Coordination Secretariat/ Ministry of Water Resources River Development and Ganga Rejuvenation, (PCS/MoWR) and National Institute of Hydrology (NIH).

[4] The new HP-II states are Goa, Himachal Pradesh, Puducherry and Punjab with the new HP-II central agencies being Central Pollution Control Board (CPCB) and Bhakra-Beas Management Board (BBMB).

intensifying its use in effective and efficient water resources planning and management. A longer-term goal of the project was to assist the central and state governments in addressing the issues of intra-sectoral demands and overall resource planning and management through the establishment of core hydrological organizations.

3. **Rationale for Bank assistance:** The Government of India (GoI) requested continuation of its successful partnership with the World Bank in developing and promoting HIS under HP-I for the design and implementation of HP-II. GoI turned to the Bank for its global experience and knowledge in establishing water resources information systems. Moreover, the strategic alliance with the Bank for the implementation of HP-II would also benefit from the strong comparative advantage gained through its long association with both central and state governments in the water resources sector. This was expected to help achieve a comprehensive view of the sector's overall development needs and help define the country's long-term water management strategy. The proposed HP-II project would strengthen the HIS foundation of HP-I, to ensure that all future water sector activities, including Bank-funded programs, will be developed on the basis of a robust hydrological database and will use sound analytical and HIS-based decision support tools, design aids and methodologies for planning, design, operation and management.

## 1.2 Original Project Development Objectives (PDO)

4. The Project Development Objective (PDO) aimed at "extending and promoting the sustained and effective use of the HIS by all potential users concerned with water resources planning and management, both public and private, thereby contributing to improved productivity and cost-effectiveness of water-related investments in 13 states and eight central agencies.[5]

5. The PDO would be achieved by (a) strengthening the capacity of hydrology departments (surface and ground water) to develop and sustain the use of the HIS for hydrological designs and decision tools, thus creating an enabling environment for improved integrated water resources planning and management; (b) improving the capabilities of implementing agencies at state and central level in using the HIS for efficient water resource planning and management, thereby reducing the vulnerability to floods and droughts; (c) establishing and enhancing a user-friendly, demand responsive and easy accessible HIS to improve a shared vision and transparency of HIS between all users; and (d) improving access to the HIS by public agencies, civil society organizations and the private sector through awareness building supporting outreach services. Greater use of an improved HIS was expected to have a broad but definite impact on the planning and design of water resources schemes, from which the rural and urban poor will have secure and sustainable access to water for multi-purpose livelihood uses. Outcome indicators as provided in the Project Appraisal Document (PAD) and Implementation Status and Results (ISRs) are as follows:

### PDO Indicator

6. HIS mainstreamed by IAs and used by all Hydrologic Data User Group (HDUG) members and individuals to meet their planning and design requirements.

[5] See previous two footnotes for HP-II agencies; IMD opted out of the Project in the early stages of Project implementation.

**Intermediate Results Indicators**

7. **Component 1:** Agencies have the necessary capacity to use and promote the broad use of HIS among private and public sector users as well as to develop proactive response systems for HDUG needs.

- IAs strengthened with requisite trained staff in place;
- HIS fully equipped, operational, functioning effectively and provided with adequate O&M funds; and
- Proactive HDUGs representing water resources stakeholders are in place.

8. **Component 2:** All concerned agencies/users adopting hydrological design aids and Decision Support System (DSS) tools for water resources planning and management, and purpose-driven studies have contributed to knowledge advances in the country's water sector.

- Fifty percent of targeted hydrological design aids (HDA) developed in the IAs have been incorporated into standard practice;
- In 75 percent of agencies where DSSs have been successfully piloted, [these] are being replicated through in-house expertise; and
- At least 10 different types of private sector entities in each state are using HIS data and design aids.

9. **Component 3:** HIS established in the four new states and two new central agencies with transparent and easy access to data provided for all.

- Eighty percent of new HP agencies is equipped with a fully functional HIS (operational measurement sites/water quality labs and data processing/storage centers, etc.) and
- At least 10 different types of private sector entities in each state are using HIS data and design aids.

### 1.3 Revised PDO

10. The original PDO and indicators remained unchanged during project implementation.

### 1.4 Main Beneficiaries

11. The PAD did not identify specific beneficiaries of the project, other than ‘HIS data users’, referring mainly to “potential data users concerned with water resources planning and management, both public and private” and “public agencies, civil society organizations and the private sector.” During HP-I and HP-II, a large spectrum of actual data users emerged, including (local) government departments and bodies, municipal corporations, water supply agencies, industries, farmers, non-governmental organizations (NGOs), consultants and individuals, and academic researchers. Data are predominantly acquired for infrastructure design purposes (e.g. structures, schemes, roads, flood levels), research, assessment of hydropower potential and irrigation management, and for the settlement of water disputes and insurance claims. The second large category of HIS data use is for water resources planning within the State Water Resources Departments, particularly for minor and medium irrigation projects, and for ground water (GW) assessments, which are of particular

importance in districts with (near) over-exploitation of GW. Several GW agencies have widely introduced HIS data and GW assessments in the farmer's community for sustainable and participatory GW management. Surface water agencies also collaborate with disaster and drought management agencies. Thirdly, individuals and non-government entities use data for academic and/or scientific investigations.

### 1.5 Original Components *(as approved)*

12. The project results were to be achieved through the following three components at a total cost of US$135.05[6] million, of which US$105.51 million would be financed by the Bank:

13. **Component 1:** Institutional strengthening (US$49.38 million) covering all 13 states and eight central agencies. This would be achieved through:

- Consolidation of HP-I activities in the nine existing HP-I states, including extended training in HIS data processing, software and water quality equipment use; supporting equipment maintenance; upgrading hardware/software and hydrometric equipment and network capacity;
- Awareness raising, dissemination and knowledge sharing, and training of personnel, including the creation of resource material, publications, website development, workshops, trainings programs and study tours; and
- Implementation support, including assistance with monitoring and learning, financial management, planning tools and Management Information System (MIS), organizational development and process improvement.

14. **Component 2:** Vertical Extension (PAD: US$58.95 million) covering the nine existing HP-I states and eight central agencies, including Central Pollution Control Board (CPCB) and Bhakra-Beas Management Board (BBMB). This would provide for:

- The development of HDAs, that is, the development and pilot application of standardized HDAs for SW, GW and water quality;
- The development of DSS for water resources planning purposes, that is, the development of DSS systems for: (i) water resources planning and basic operations; and for (ii) advanced real-time operational use for the Bhakra-Beas river/reservoir system under BBMB and for flood forecasting in the Mahanadi basin; and
- The implementation of Purpose Driven Studies (PDS)

15. **Component 3:** Horizontal Expansion (PAD: US$26.72 million) covering four new HP states. This would provide support to Himachal Pradesh, Goa, Puducherry and Punjab for:

- The upgrading and establishment of data collection networks, including river gauging stations, GW observation wells and aquifer monitoring systems, meteorological stations and water quality monitoring stations and laboratories;

[6] Amount includes physical and price contingencies as well as the financing of mainly taxes and recurrent cost by the states and GoI.

- The establishment of data processing and management systems, including: the development of HIS as per the HP-I approach, establishment of data communication linkages for validation and exchange of data and information, and procurement of the necessary hardware, software and civil works for the Data Processing Centers;
- The implementation of PDS; and
- Formal training and on-the-job training.

### 1.6 Revised Components: N/A; see also Section 1.7.

### 1.7 Other Significant Changes

16. **Broadening hydro-meteorological monitoring through innovative and advanced tools:** Since the project did not envisage upgrading of the HIS already developed under HP-I, no provision was made to substantially modernize it in HP-I states. The Mid-Term Review (MTR) recognized the importance of using improved technology for providing data in a timely manner with improved reliability for various water management applications. This change in strategy introduced opportunities to transform manual monitoring systems into automated and real-time monitoring systems (RTDAS) in all project states; and transformation of desktop-based database management software system into centralized web-based systems. Consistent with MTR recommendations, the following changes were introduced during and after MTR: i) upgrading of the hydro-meteorological monitoring system from a manual to an automated set-up for surface and ground water and water quality in all the states; ii) introduction of real-time water quality monitoring stations by CPCB and Central Water Commission (CWC) in the Ganga Basin; iii) development of centralized web-based software systems for data processing, storage and dissemination; iv) development of a real-time flood management and reservoir operation system for the Upper Krishna and Upper Bhima River Basins in Maharashtra; and v) introduction of advanced aquifer mapping techniques including advanced airborne Transient Electro-Magnetic (TEM) geophysical surveys in six pilot watersheds. The latter aimed to test the efficacy of advance geo-physical techniques for the country-wide National Aquifer Mapping program (NAQUIM). These changes matched emerging needs of implementing agencies and reflected programs envisaged under the 12th Five Year Plan (FYP). The World Bank management approved reallocations within the project budget and allowed a flexible approach to accommodate the new demands.

17. **Extension of Closing Date:** The project duration was extended by 23 months in March 2012. This shifted the project closure date from 30 June 2012 to 31 May, 2014. The extension of the closing date was warranted mainly on account of (i) allowing sufficient time and technical assistance to establish, troubleshoot and commission the novel technologies introduced post-MTR; (ii) catching up for initial implementation delays in order to enable completion of activities already started; and (iii) allowing for more time to successfully carry out public awareness and data dissemination through the establishment of websites by all agencies and organizing various forums.

## 2. Key Factors Affecting Implementation and Outcomes

### 2.1 Project Preparation, Design, and Quality at Entry

18. **Comprehensive and relevant design:** Project preparation efforts were substantial with active participation of the national agencies and several Bank missions. The Quality at Entry Review (QER) Panel concluded in February 2004 that the Project was well-developed and the processing time table

was realistic. At the time, the Project was strategically aligned with India's development goals and the Country Assistance Strategy (CAS), and it still is today (see Section 3.1). Project preparation drew on the experience and detailed lessons learned from HP-I. The scaling-up and consolidation of HP-I activities through horizontal expansion, the further development of the HIS model through vertical expansion, and the institutional strengthening component developed with the active participation of central and state level agencies are good indications of the comprehensiveness and technical soundness of the design. Further, the project design allowed sufficient flexibility during implementation to accommodate most of the emerging needs of IAs. The design of the institutional component was (on purpose) kept rather light and did not raise expectations towards substantive institutional changes within IAs.

19. **Proven model for implementation arrangements:** The proposed implementation arrangements for the Project already existed under HP-I with reasonably demonstrated effectiveness. Institutional and technical lessons learned from HP-I[7] were reflected in the project design of HP-II. The PAD did not propose any major policy and institutional reforms other than proposing a gradual transition of the existing Project Coordinating Secretariat (PCS) into a permanent HIS Cell. The QER Panel also stressed the importance of the management consultants to support institutional change from a hydrological information focus to a sustainable institutional arrangement for HIS. However, the challenges experienced during initial period of the Project might have been avoided in case specific legal covenants had been triggered during preparation to ensure readiness for the Project effectiveness, including the transition of PCS into a permanent HIS Cell and the timely mobilization of the crucial Technical Assistance and Management Consultancy (TAMC) (which got delayed until February 2009). Moreover, the PAD did not incorporate specific provisions requiring states with separate SW and GW departments, but overseen by the same Principle Secretary, to integrate their work programs under the Project so as to act as one IA interacting with PCS/Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD&GR) and the Bank, thereby facilitating efficient project management.

20. **Fiduciary arrangements:** The Project's fiduciary arrangements were designed around domestic procedures and built on experience and systems evolved during HP-I. The PAD did not envisage many procurement issues beyond "normal delays in implementation." However, the PAD may not have appreciated that much of the procurement expertise built-up in the IAs during HP-I had "evaporated" by the time HP-II started (two years after Board approval), nor did it consider remedial measures for the inordinate procurement delays occurring in the approval process particularly by the Expenditure Finance Committee (EFC). The PAD had put several covenants in place to ensure adequate FM.

21. **Monitoring & Learning/Evaluation (M&L/E) arrangements:** While the PAD outlined as such the correct approach to M&L/E, it did not elaborate sufficient specific and measurable outcome and results indicators (see also Section 2.3).

22. **Critical risks:** The risk assessment was overall adequate. Critical risks identified in the PAD required strong commitment from the IAs relating to (i) adequately and timely funding for the Project;

[7] Institutional lessons learned under HP-I concerned: i) The need for three HIS Management Groups and a strengthened HIS Coordination Secretariat; ii) the need to promote data dissemination and use; iii) continuity of specialist and other key staff; iv) strengthened procurement arrangements; and v) development of benefit monitoring mechanism as part of M&E/L.

(ii) exhibiting a willingness and proactive attitude towards sharing data with public and private potential users as well as in bringing about positive multiplier effects beyond the immediate beneficiaries; and (iii) deploying specialists and multidisciplinary staff and their continuation for a minimum duration. The Project has not faced serious funding issues. In later years, the new Hydrological Data Dissemination Policy of MoWR, RD&GR contributed largely to effective hydrological data dissemination in several states through websites (e.g. Karnataka, Maharashtra, Puducherry and Tamil Nadu). Project implementation does not appear to have suffered significantly from issues related to incremental and specialized staff. Risks were adequately managed by the project design allowing for flexible planning and procurement with adjustable piloting, technical support and adjustable annual work programs. Other technical risks were minimized by drawing upon international experience in designing real-time (RT) DSS systems, using state-of-the-art methods and equipment for extending HIS to the new states, and sharing the lessons learned in each project activity areas among all IAs.

23. **Quality at Entry:** Overall, the Quality at Entry was strong. The project was technically sound, highly relevant in the Indian context and prepared making good use of lessons learned from HP-I. Risks were adequately assessed and proper mitigation measures put in place. The implementation and fiduciary arrangements were appropriately built on the proven structures of HP-I, but a stronger focus on ensuring full readiness of the implementation arrangements would have been beneficial.

## 2.2 Implementation

24. **Slow start-up:** Project effectiveness was delayed by about 18 months due to delayed clearance of the EFC in MoWR, RD&GR. This signaled an initial lack of interest of MoWR, RD&GR in the Project, which snowballed into long delays in the mobilization of key support consultancies. The linkage of procurement of various goods and equipment with these key consultancies further contributed to start-up delays to the extent that the Project became a problem project around 2007-08. The ISR of November 2008, observing that "the PCS is woefully short-staffed, and there is complete lack of leadership/direction from the Centre," considered imposing suspension of disbursements, reduction in project scope and cancellation of funds. However, project implementation began to improve after MTR in 2009, when several decentralized activities were introduced and three key consultancies were mobilized.

25. **Varied performance by IAs:** Implementation performance varied among the 28 agencies involved, with a strong correlation between agency performance and the importance assigned to HIS by the leadership in the agencies. Himachal Pradesh set a good example of continuing leadership with the same official despite promotion/transfer. Similarly, leadership in some agencies, including Gujarat, Kerala, Karnataka and Maharashtra, became champions in demonstrating the usefulness of PDS and DSS planning systems in water resources planning. Punjab, Madhya Pradesh, Odisha and later Karnataka-GW, on the other hand, suffered due to varying commitments from senior management. The frequent transfer of HP-staff to other priority programs as witnessed under HP-I, both at senior management level (often insufficiently committed to HP) and operational level (particularly affecting SW-related activities), continued to be an issue in some states, affecting project planning, coordination and implementation. States with good performance such as Himachal Pradesh, Maharashtra, Goa and Puducherry had minimal turnover of key staff, while Odisha, Madhya Pradesh and Karnataka-GW have experienced more turnover and rather inadequate staffing. Karnataka-GW transferred most of the staff working on HP-II midway in the Project; thereafter, the performance of the department dropped significantly.

26. **MTR:** The MTR, held in October 2009, did not propose changes to the original PDO, project components or overall project financing even though progress differed among components and actual utilization of the loan for project implementation stood only at US$11 million (10.5 percent). Nonetheless, the MTR mission concluded that the Project made significant progress towards the achievement of the PDO and that the PDO continued to be both relevant and achievable. The MTR removed strategic bottlenecks due to the concentration of Project activities at the central level and over dependence of implementation on the engagement of centralized key consultancies. Funds were reallocated from underperforming IAs to higher performing IAs and across project components to cater to emerging specific requirements. Cost savings and contingencies were agreed to be reallocated towards the introduction of advanced real-time automated hydro-meteorological monitoring system in all the states and other systems as listed in Section 1.7. These systems significantly enhanced the ability of water professionals to address a range of water-related risks (for example, floods, droughts) and have proven to be successful project interventions. Disbursement percentages were also changed to 100 percent for Goods and Consultant Services and 75 percent for Operating Costs, to simplify the loan disbursement procedures for the Borrower and ensure effective overall implementation of the Project.

27. **Implementation and procurement delays:** In order to have National Standardized software and modelling systems, the Project was primarily centered around the procurement of centralized major international consultancies (quality based) which was for the first time in the country. Due to inexperience in engaging international consultancies, the consultancies were mobilized with large delays and procurements of novel and sophisticated equipment experienced similar delays due to limited capacity of IAs regarding engaging international bidders/suppliers, compounded by a shortage of qualified bidders in the country. The general shortage of specialized staff with IT and water quality skills in state governments still exists, but was creatively addressed in some agencies by outsourcing or hiring staff from private agencies. Queries raised by (central and state) Finance Departments and other administrative obstacles contributed to slow procurement processes, leading to slow disbursements and delays in delivering the work program.

28. **In summary**, Implementation Progress (IP) was slow till MTR, flagging shortcomings in Project Management. Thereafter IP gradually accelerated, due to restructuring, improved performance of PCS and mobilization of key consultancies. Following reduction in barriers for participating HP-II IAs, the project succeeded in developing/augmenting HIS networks, develop applications and technologies for improved water management using HIS data, and change in culture of agencies towards dissemination of HIS. Furthermore, several innovative practices extended beyond original targets, providing water managers with real-time management tools and disseminating data to the public via web-based portals.

### 2.3 Monitoring and Evaluation, Design, Implementation and Utilization

29. **M&L/E Design:** The Project's M&L/E Design intended to assess (i) performance; (ii) institutional tracking for organizational learning; (iii) internal learning for developing project processes; and (iv) evaluation for measuring project impacts and outcomes. The QER Panel felt that M&L/E indicators needed to be more focused and outcome based. Accordingly, the PAD stipulated in its Annex 9 that HP-II would develop a benefit monitoring mechanism using academic institutions and specific consultancies to develop assessments of value-addition. Training in monitoring and assessing

benefits from data use was also included. However, M&L/E indicators included in the PAD lacked clarity and were difficult to measure.

30. **M&E implementation and utilization:** PCS focused (under the pressure of implementation and limited resources) essentially on the monitoring of physical and financial progress. Annual work plans and procurement plans were generally compiled by PCS in a timely manner. Semi-Annual Progress Reports (SAPRs) tracked mainly the progress of physical and financial inputs and the completion of activities in the Project Implementation Plan (PIP). In parallel, the PCS and Bank team evaluated the performance of all IAs consistently against the metrics essentially consisting of i) percentage completion of annual work program; ii) size of work program; iii) proactivity in procurement of work program; iv) submission of financial information; and v) staff. This introduced competition among agencies to perform and allowed continuous adjustments (and reallocations) to be made to the overall work program to ensure maximum utilization of the available financial resources. Since the major attention of both the World Bank and PCS was towards expediting the physical progress of project, and significant benefits started showing up only during the last year of the project, the envisaged studies on benefits and user satisfaction surveys could not take place. Following MTR, the indicators set during the design could have usefully been improved to provide a clearer basis for monitoring progress.

## 2.4 Safeguard and Fiduciary Compliance

31. **Safeguards:** The Project only triggered the environmental safeguard policy as it is a service operation and involved only minor physical works. It was thus correctly rated as a Category "C" project. The triggered OP-4.01 has been applied to various proposed activities to screen the Project. From the safeguard perspective, the only issue needing specific attention concerned the construction of civil structures under the Project (data centers, offices, monitoring stations, cable ways, and so on). Because the Project was essentially implemented by engineering organizations, the Task Team relied on their effectiveness regarding construction and campsite management, and safety aspects. Compliance to the Environmental and Social Safeguards has accordingly been rated as *Satisfactory*.

32. **Procurement:** The project included procurement of national and international consultancies and of several innovative systems which were being introduced for the first time in India. As explained above, it proved challenging for project staff to process, evaluate and manage such contracts. This was aggravated by the late mobilization of a procurement specialist. Nonetheless, most of the procurements were completed at closure albeit often with significant delays affecting the implementation progress of the project. Efforts were made to strengthen the capacity of staff through technical and commercial training and through consultations with international experts, sometimes supported by Trust Funds arranged by the World Bank.

33. To improve the quality and reliability of technically innovative equipment procured under the Project, procurements under HP-II mandatorily required extended warranty periods (at least two years) and a minimum of three years of comprehensive Annual Maintenance Contracts (AMC) following the warranty period, while the cost of AMC was included in the overall bid evaluation. This has improved the quality and sustainability of equipment and software systems procured under the Project.

34. **Financial Management:** Overall, the Project has performed financial management moderately effectively. Accounting procedures and financial reporting arrangements to be followed by all IAs were standardized. National Water Academy (NWA) successfully developed web-enabled Financial

Management Report (FMR) software complying with the Bank's reporting requirements, supported with training. Since the web-based FMR system for HP-II has already been developed and was used by all IAs, there is scope in the future for moving from the Statement of Expenses (SOE) to FMR based disbursement and submission of one consolidated FMR at the end of every month/quarter. The financial management capacities at state level were found to be adequate throughout the project implementation period. A dedicated finance desk at MoWR, RD&GR would have helped in timely reconciling FMRs. Most agencies have regularly submitted their SOE claims to the Bank.

## 2.5 Post-completion Operation/Next Phase

35. **Post-project completion of HP-II interventions (spill-over):** There is a spill-over of financial commitments beyond Project closure, estimated at about US$5.5 million. This is mainly due to the late award of contracts for software development and real-time data acquisition systems, completion of the construction of the State Data Centre of Punjab and completing adequate arrangements for training, dissemination and deployment of target users of the software developed under the project. There are thus three categories of cost to be borne by the IAs after Project closure: i) cost of completion of spill-over contracts; ii) cost of ongoing AMC contracts for advanced software and equipment systems; and iii) ongoing recurring cost for operation and maintenance (O&M) of the HIS. All involved agencies have positively committed to make the required funding available for the spill-over works as per the actual needs, and for the continuation of already concluded AMC contracts. Moreover, about two-third of IAs have policies, budgets and training plans in place for sustainability of HIS, while others have started to rely on regular budget provisions. Therefore, the ICR mission assessed that funding of the post-completion of Project activities does not pose a serious threat to the sustainability of the HIS.

36. **Sustainability of the HIS:** Both the new National Water Policy (2012) and the 12$^{th}$ FYP stress the need for a national level information system for water resource management and planning, which are driving forces for HIS sustainability. There are also a number of encouraging developments supporting sustainability of the HIS, *inter alia*:

***Centralized Initiatives:***

- CWC has introduced a web-based India-WRIS for the country, in order to develop a national water database covering all states (joint venture of CWC and Indian Space Research Organization (ISRO)). It aims to provide a 'single window' solution for comprehensive and consistent data on India's water and natural resources, along with tools for data analysis, water resource assessments and IWRM;
- MoWR, RD&GR plans to set-up the National Water Informatics Center (NWIC) with the objective to generate, organize and provide an up-to-date water database in the public domain and develop value-added products and services for IWRM in India;
- MoWR, RD&GR has allocated funds for the automation of the hydro-meteorological information network in the country and for scaling-up some of the activities funded under the project. CWC has already introduced real-time monitoring systems at 480 sites;
- Central Ground Water Board (CGWB) is in the process of implementing NAQUIM, guided by the six pilot aquifer mapping projects carried out under HP-II, with the aim to introduce and strengthen community based GW management;

- The importance of the monitoring of water uses, particularly in irrigation systems (as the major water user), has been recognized as a critical area in the O&M of water resources systems in India with an urgent need to improve water use efficiency in the country;

***Initiatives by IAs***

- Some states have taken steps to further the activities of HP-II from state funding, including the installation of additional monitoring stations, aquifer mapping, the recruitment of young engineers dedicated to extending the DSS-P system for IWRM applications in other river basins, and building hydrological modelling capabilities within the department. Some have also set up a real-time flood and reservoir monitoring cell;
- Several state agencies have proactively strengthened their capacity with the help of training from various institutes and have developed arrangements with local institutions for regular staff training; and
- Several non-HP-II states have indicated keen interest in upgrading their monitoring systems to the HIS standards of the Hydrology Project, which has led MoWR, RD&GR and the DEA to propose a follow-up Hydrology Project Phase-III (HP-III).

37. **Follow-up HIS project interventions (HP-III):** Two stakeholder workshops organized by PCS and the Bank (refer section 3.6 for details) where the participants were unanimous in their recommendation that the HIS systems and applications developed under the Hydrology Project be scaled-up for the entire country including non-HP states and that the HIS should move towards supporting IWRM practices. MoWR, RD&GR acknowledged the demands of the IAs and confirmed the need for expanding the HIS as implemented under the Hydrology Project to all non-HP states, including the Ganga and Brahmaputra River basins (classified data), while providing further development of the HIS and institutional strengthening in all states. Accordingly, the World Bank received a request from DEA for funding of a nation-wide Hydrology Project Phase III.

38. **Fiscal impact of HIS:** Overall, the fiscal impact of the Hydrology Project on the annual budgets of state agencies is expected to be minimal. A good example is Maharashtra which implemented a comprehensive (and the largest in the project) real-time monitoring and flood forecasting system under HP-II inclusive of approximately 250 real-time monitoring systems and covering 40 major multipurpose dams. For FY 2014-15, the total budget for Maharashtra's Water Resources Department is INR 130,685 million and the annual budget for the office of the Chief Engineer-Hydrology of this state is INR 306 million. Of the latter, the annual O&M budget for this year for running the HIS network is only INR 21.2 million, or a mere seven percent of the Chief Engineer's budget.

## 3. Assessment of Outcomes

### 3.1 Relevance of Objectives, Design and Implementation

**Rating for Relevance of Objectives: *High***
**Rating for Relevance of Design and Implementation: *Substantial***

39. **Relevance of PDO:** The PDO, initially pursued through HP-I and later broadened and explicitly articulated in HP-II was and remains today *highly relevant* to India's water resources development and management needs. The PDO reflects GoI's current priorities in the water sector as

endorsed in India's 12th FYP (2012-17) and in India's new National Water Policy (NWP, 2012). Both documents underpin the need for institutional arrangements, along with appropriate training, to maintain a robust and transparent hydrologic database as a prime requisite for surface and ground water resources planning as well as to move towards water allocation criteria based on reliable hydrological analysis. Moreover, the PDO is consistent with the Bank's Country Partnership Strategy (CPS), 2013-17, India's Water CAS and the Bank's Corporate Water Sector Strategy (CWAS) for promoting optimal water resources development and IWRM. The strategies not only emphasize the crucial need for water and environmental data for adequate design and maintenance of infrastructure in the water and agriculture sectors as well as for water supply and industrial development, but also necessitate the development of a free standing project, focusing on the institutionalization of hydrological data to cater to the needs of water resources planning, allocation, management and regulation.

40. **Relevance of Project Design and Implementation**: Project design and implementation is consistent with the stated PDO and remains relevant in terms of developing and mainstreaming the HIS by all agencies involved. The recent adoption by MoWR, RD&GR of new Hydro-meteorological Data Dissemination and National Water Policies and the development of the India-WRIS point to the contributions project implementation has made to the observed paradigm shift towards IWRM in India. A key strength of Project design has been the flexibility to adjust and adapt to evolving needs brought forward by the implementing agencies, including adjustments to budget allocations. Furthermore, while highlighting the critical importance of HP-I and HP-II, MoWR, RD&GR and DEA have requested for extension of the Bank's support for the country-wide scale-up of the Hydrology Project, which is a clear reflection of the significance of the project design and its successful implementation. Strength of the design was also indicated in the participatory process involving all IAs through numerous workshops. However, as already discussed in Section 2.1, Project design could have (i) spelled out specific legal covenants regarding the establishment of a permanent HIS Cell; (ii) specified early readiness conditions in terms of administrative approvals and upfront processing of critical procurements; and (iii) elaborated more easily measurable outcome indicators.

### 3.2 Achievement of Project Development Objectives

**Rating: *Substantial***

41. The Project contributed significantly to a strategic shift and paradigm change in the hydro-informatics and water management scenario of the country including shifts from:

- collection and collation of historic data to more reliable and real-time monitoring and improved transmission to users;
- strict ownership of data by different agencies and states to inter-agency sharing of data;
- traditional static use of data to using modern analytical tools to enhance data use for mission critical operations and IWRM;
- limited data use by isolated development projects to improved planning and water management at river basin scale.

42. Additionally, the Project increased the use of HIS for the technical and administrative clearance mechanisms for hydraulic structures (supply side investments) as well as industrial investments (demand side investments as water users). The Project brought about an increased interest in IWRM at river basin scale, requiring inter-state cooperation and data sharing on water issues. These shifts and

resulting need for reforms crystallized in the announcement of India's new Hydro-meteorological Data Dissemination Policy (2013), articulating an emphasis on free data sharing between state and central IAs and with the public at large.

43. Overall, the project has surpassed the majority of its original technical targets. Detailed project outputs and outcomes are discussed in Annexes 2 and 3. Key achievements have been the introduction of state-of-the-art monitoring equipment and tools, including:

- **Real-time hydro-meteorological systems and RTDAS in 11 states and three river basins (against the target of two river basins).** The real-time water quantity and quality stations are helping to manage floods, reservoir operations and water quality leading to improved productivity and efficiency of systems in timely manner. In particular, water quality stations (against nil target in the project) in the Ganga Basin have been of great benefit to assess the water quality in the largest river basin and in particular to manage the Kumbh fair when an estimated 100 million people gathered to take a holy dip in the Ganga River;
- **Tools and DSS for flood forecasting in three basins (against a target of two) and for water resources management in 13 river basins (as per target).** The real-time flood forecasting systems for BBMB and the Upper Krishna and Upper Bhima River Basins in Maharashtra positively impact millions of people, primarily the poor and manage irrigation water distribution;
- **Advance geophysical surveys** in six pilot areas (against nil targets) to provide recommendations for advance geo-physical tests in the NAQUIM for GW management;
- **India-WRIS:** A breakthrough in India has been the introduction of the National Data Dissemination Policy and the sharing of historical and real-time hydro-meteorological data for the country through MoWR, RD&GR's web-based India-WRIS developed by CWC through its own funds; and
- **Improved and Cost effective solutions:** The HIS and tools developed in the project have contributed to substantial savings for state agencies in the range of INR 150 million (US$ 2.5 million) to more than 1,000 million (US$ 17 million). Among various savings, the noteworthy were reduced flood damages and improved designs of new structures for augmenting water supplies.

*44.* The Results Framework of the PAD provided only one PDO indicator: "HIS mainstreamed by 90 percent of IAs and consistently used by them as well as by HDUG members and individuals to meet their planning and design requirements". To provide a more complete assessment of the objective achievements, the ICR mission inferred the intended objectives from key associated outcome targets and the operation's design features[8], and reviewed and assessed four elements of the PDO to bring out project achievements: (i) *consolidating, mainstreaming and upgrading the HIS;* (ii) *sustained and effective use of the HIS;* (iii) *improved water resources planning and management; and (iv) improved productivity and cost-effectiveness of water-related investments.*

[8] See Appendix A, page 33 of the ICR Guidelines, updated July 22, 2014.

### 3.2.1. Consolidating, Mainstreaming and Upgrading of HIS

45. The project has been able to successfully establish and enhance a user-friendly, demand responsive and easily accessible HIS, contributing significantly to the goals set under India's 12th FYP 2012-17. Post MTR, the upgrading of HIS primarily focused on transforming the existing manual monitoring system to real-time monitoring and transforming desktop-based software for database management to web-based software, in order to improve data accessibility and the operation of systems. Important achievements include:

- **HIS monitoring networks were extended, upgraded and consolidated in the existing nine HP-I states, and newly established in four new states.** Standardized database systems for data entry processing and storage for SW, GW and water quality are introduced to facilitate data exchange and validation among states and central agencies. Some of the HP1 IAs (for example, Andhra Pradesh - GW, Gujarat - GW, Karnataka SW, Maharashtra - SW and Tamil Nadu) outperformed their PAD targets in upgrading of HIS network. All new HP-II states substantially achieved or exceeded HIS development targets including the introduction of RTDAS. Himachal Pradesh[9] and Goa have been excellent performers while Puducherry has shown good performance. Punjab has got a functioning HIS and is completing its new State Data Center building by committing its own resources for project completion;
- **Real-time hydro-meteorological monitoring system introduced:** Hydro-meteorological monitoring stations have been equipped with RTDAS in 11 states and BBMB (against a target of two river basins), thereby providing data on real-time basis for supporting critical operations like reservoir management, GW abstractions, flood forecasting and control, drought management, and so on. RTDASs were initiated for the first time in all HP-I states as additional targets except in Kerala and Chhattisgarh, including real-time reporting weather stations, river and reservoir gauging stations, and GW monitoring;
- **Water quality data collection and management enhanced:** Water quality data collection and management focused on upgrading laboratories in HP-I states and the development of new facilities in new states. CWC and CPCB successfully installed 13 real-time water quality monitoring systems on a trial basis, setting an example of real-time water quality monitoring for managing water quality and serving the Bank-funded Ganga Project;
- **Easy access to shared information:** The joint venture of CWC with ISRO (funded by MoWR, RD&GR) established a comprehensive spatial India-WRIS for the whole country to implement the National Data Dissemination Policy, which aims at sharing free of cost information across sectors including hydro-meteorological data for the entire country, and serves as an exchange platform for the states. In tandem, several IAs have also initiated data sharing through their own websites;
- **Data quality and validation practiced:** CGWB and IMD have participated adequately in inter-agency data validation, while CWC needs to further catch up with this important work. This is critical in view of inter-state water issues, data quality control and maintaining country-wide uniformity in data collection practices and standards; and
- **Advanced geophysical surveys introduced:** Though not originally planned, CGWB successfully executed six pilot projects for advanced airborne TEM geophysical surveys, to demonstrate the

[9] Success factors in Himachal Pradesh were: i) the state has a single agency for SW and GW; ii) continuity in staffing; iii) support from policy levels in the state government; iv) linkages with other government departments; and v) formal arrangement of data sharing with critical stakeholders through a signed Memorandum of Understanding (MoU).

cost effective use of advanced techniques for aquifer mapping in preparation of NAQUIM and National Aquifer Management program.

### 3.2.2. Sustained and Effective Use of the HIS

46. The assessment is that the Project has institutionalized the coordination, management and use of the HIS, thereby consolidating the gains achieved under the project and sustaining the investments made. The sustained and effective use of HIS has been assessed as substantially achieved:

- **Effective information dissemination:** To promote and facilitate information dissemination, the agencies have activated websites to share meta-data on historical as well as real-time hydro-meteorological and GW data. Maharashtra, Karnataka and Tamil Nadu excelled in actual data dissemination. Several agencies are also sharing real-time hydro-meteorological data on their websites;
- **Policy formulation on access to information:** MoWR, RD&GR constituted a task force on Hydrological Information Needs Assessment, findings of which contributed to the establishment of a new National Hydro-meteorological Data Dissemination Policy (2013) for India. This policy entitles any web-registered user to download all unclassified hydro-meteorological data hosted on the India-WRIS website, free of cost;
- **Sustainably financed programs:** One-third of the agencies have started HIS related programs funded through their own resources; two-third of the agencies have put in place policies, earmarked budgets and drawn-up training plans to ensure sustainability of HIS;
- **Diversity of users:** All agencies have set-up a HIS website accessible to a wide range of users, formally formed a HDUG, organized HDUG meetings and disseminated HIS data to HDUG members, including the private sector. The data users include a wide range of government departments, academicians, civil society organizations, private sector as well as 'concerned citizens';
- **From data collection to system and application development:** Most IAs have graduated from being mere data collectors to application developers and transitioned from desktop-based systems to standardized national web-based software system (with no financial liability of states) through:[10] (i) e-SWIS (Surface Water Information System) developed by CWC; (ii) e-GEMS (GW Estimation and Management System) for GW database and estimation by CGWB; and (iii) e-WQIS (Water Quality Information System), a web portal for publishing real-time water quality data, developed by CPCB. Pending the completion of these new systems, initiated post-MTR in 2012-13, agencies have made data available through their own websites. CWC has already started disseminating real-time flood level data across India through e-SWIS; and
- **Seven World Bank supported projects benefitted from data support and information provided by the Project.** The experience gained by the Bank and IAs with the technical and commercial aspects of introducing several innovative technical systems is now available to guide non-HP states and other inter-sectoral bank funded projects; all important HIS documents and technical specifications are available on http://www.indiawrm.org.

[10] These systems will ultimately serve the entire country and would provide a standardized national platform for the exchange and consolidation of hydro-meteorological databases. The web-based e-GEMS for GW data storage and processing has been tested for pilot and is expected to be ready for deployment to states by February 2015. The web-based e-SWIS system for SW data storage and processing has been commissioned in November 2014. The development of the web-based e-WQIS by CPCB is expected to be completed and online by December 2014.

### 3.2.3. Improved Water Resource Planning and Management

47. Three significant advancements in the use of HIS for improved water resource planning and management were noted that also contributed to improved productivity and cost effectiveness of water related investments: (i) development of DSSs; (ii) conceptualization and carrying out of PDS; and (iii) development of HDAs. The DSSs for planning are set up for all 13 targeted river basins in the nine HP-I states. Addition of real-time technologies have enhanced the DSS, adding to critical practical applications such as SW planning, GW use planning, integrated reservoir operations, irrigation management, drought monitoring and management, conjunctive use of SW, GW quality management, and flood forecasting and management. In states such as Kerala and Gujarat, replication of DSS-P has already been initiated in other basins. Thirty-eight PDSs were successfully completed, covering a broad spectrum of water-related issues like water quality, GW development, reservoir sedimentation, urban hydrology and the like. Most studies yielded excellent and practical results which could be used by all user stakeholders. The standardization of hydrological design practices needs more time. Therefore, HDAs could not yet be rolled out to the participating agencies and non-HP states to bring about standardization of hydrological design practices.

### 3.2.4. Improved productivity and cost-effectiveness of water-related investments

48. Use of HIS and its applications in investment decision making and operational management has led to improved productivity and cost effectiveness (See Annexure 3). Some noteworthy examples include:

49. **Minimizing flood damages:** Reservoir operation based on real-time data and support systems resulted in increased irrigated area as well as reduced flood damage. For example, in the Bhakra Beas system the damages during floods of 2007 and 2010 were in the range of INR 1,058 million (US$17.6 million) with a loss of 23 lives. Such losses were avoided during a similar flooding event in 2013 after the commissioning of RT-DSS. Further, increase in water availability contributed to both an increase in irrigated area of 56,000 ha while also contributing to an increase in hydropower generation. In the Upper Krishna River Basin in Maharashtra, the flood damages were in the range of INR 3,931 million (about US$65 million) and loss of 68 lives during 2006 which could have been avoided to great extent if RT-DSS commissioned last year had existed (See Annex 3, para 56-61).

50. **Savings in investments of water supply structures:** Several agencies used the HIS and DSS tools to optimize designs in an environmentally viable manner. For example, Maharashtra optimized the pipeline for water supply to Pune that lead to energy savings of 8.78 gigawatt hour/year and INR 38.3 Million per year (USD 6.4 million/per year) and Kerala used the DSS (P) to assess the feasibility of check dams for augmenting water supply to a major city and saved INR 150 million (USD 25 million).

**51. Saving in Hydromet operation and maintenance cost**: Moving from manual to real-time and automated monitoring has led to saving in 50 percent of operating costs.

### 3.3 Efficiency

**Rating: *Modest***

52. The PAD explained why a conventional economic analysis of this institutionally and technically complex project would not be possible. However, it also pointed out that reliable hydrological data are very important for the design and management of water resources development projects, and that even a small reduction in the investment costs of irrigation and flood control works would both economically justify the project and ensure its positive impact on IA budgets. Given a conventional economic analysis is not possible, the ICR focuses on the substantial benefits achieved by the project in terms of major outcomes and qualitative benefits (Annex 3). Efficiency is further assessed in terms of the project's cost-effectiveness and by a simple proxy cost-benefit analysis.

53. **Cost-effectiveness:** The project generated benefits at national, state and sub-basin levels. The analysis (Annex 3) indicates that present and future benefits far exceed the project cost. The economic value of hydrological data lies in the increased efficiency of the design or operation of water resources projects that can be achieved with good data, and in the improved robustness of water resources planning and management, that increase the net benefits obtained from the water resource. If a scheme designed with good hydrological data makes increased use of water possible compared to a scheme designed using poor data, the value of the data lies in the value of the increased amount of water that can be delivered by a well-designed project (e.g. Kerala and Maharashtra had cost effective and technically viable designs for augmenting water supply in major cities). If this is only 1 percent, then the value of the data becomes one percent of the overall scheme cost or benefits. Similarly, if increased knowledge of reservoir inflows by having good data improves operational efficiency of a scheme by five percent (for example, increasing water delivered to users with five percent), then 5 percent of the benefits derived from the project are attributable to the good data. Good data allow for smaller safety margins in design floods of structures. The 12$^{th}$ FYP estimates the damage to private infrastructure and property at US$1 billion per year with floods affecting 3.2 million people each year. A modest reduction in these annual losses and a nominal reduction in the investment costs for irrigation and flood control works would economically justify the Project investments. A noteworthy example is the RTDSS developed for the Bhakra-Beas River System that was instrumental in avoiding severe flood damages in 2013 due to improved synchronization of the releases from Bhakra and Pong Dams, and the release of excess water prior to the arrival of the flood peak based on predicted inflows (see Annex 3 for details).

54. **Proxy cost-benefit analysis:** The 12$^{th}$ FYP in India has allocated a budget of INR 2,800 billion (US$46 billion) for agriculture and water resources development. Assuming 60 percent of this budget is spent on water resources, irrigation and hydropower development across India, or some 30 percent within the HP-II project area of the 13 participating states, this would amount to INR 840 billion (US$14 billion) in the HP-II area. Assuming that good hydrological data would improve the design and operational efficiencies of these projects by at least 10 percent, this equates to a value of the data of at least US$1,400 million, equivalent to 15 times the total disbursement under HP-II (US$91.58 million). For these future benefits to be realized, GoI will need to make good use of HIS data in future system designs and operations. The Economic Internal Rate of Return (EIRR) of the Project, could it be calculated, would appear to be very high and its earn-back period short. Given the present and expected extensive future use of HIS data for project design, water resources planning, protection of water quality and other purposes (see Annex 3), it is evident that the HIS established under HP will yield significant savings on future investments and maintenance costs in the water sector.

55. This Implementation Completion and Results Report (ICRR) could thus have rated the overall efficiency of the Project as *substantial*, were it not that implementation progress and disbursement were slow till MTR in 2009, leaving ultimately US$13.4 million (13 percent) of the budget undisbursed, even though US$5.5 million will still be funded as spill-over cost by the IAs from their own resources. As reflected in the disbursement profile, achievement of the Project's outcome peaked towards its end, thanks to the impressive turnaround after MTR. Had the Project been on track earlier, the IAs could not only have fully utilized the loan amount, but more importantly, have reaped significant additional and earlier benefits from the Project's investments. Therefore, efficiency has been rated *modest.*

### 3.4 Justification of Overall Outcome Rating

**Rating: *Moderately Satisfactory***

56. In view of (i) the high relevance of the PDO and the substantial relevance of project design and its flexible and adaptive implementation; (ii) the substantial achievement of the PDO and the intended project outputs (with several outputs exceeding the original targets); and (iii) the modest implementation efficiency, the overall project outcome is rated as *moderately satisfactory*, consistent with all ISRs issued after MTR.

### 3.5 Overarching Themes, Other Outcomes and Impacts

#### *(a) Poverty Impacts, Gender Aspects and Social Development*

57. The HIS has provided and will continue to provide significant benefits to the overall social development in the country, contributing directly to poverty reduction and gender aspects in three areas: (i) reduced vulnerability to floods and droughts (for example, in Upper Bhima and Upper Krishna Basins in Maharashtra, Sutlej and Beas Basins, real-time river flow monitoring in several states); (ii) improved access to safe drinking water and related health benefits (real-time ground water monitoring in Andhra Pradesh and Maharashtra, water quality monitoring in all implementing states, PDS studies on GW quality); and (iii) increased farm incomes due to better irrigation management (real-time reservoir operations linked to weather forecasting). Given the fact that the poor (including marginal and small farmers) are generally the worst affected by the vagaries of nature and impacts of poor water quality, the project contributes positively to the prevention of loss of lives, livelihoods and property of the poor in the implementing states. Moreover, the GW management program in Andhra Pradesh had a special focus on women, since female farmers constitute a significant portion of the marginal farmers benefited by the project. Awareness building regarding water issues combined with ensuring free data access to public, NGOs and civil society organizations will contribute to overall social development.

#### *(b) Institutional Change/Strengthening*

58. The introduction of India's new Hydro-Meteorological Data Dissemination Policy (2013), the development of the web-based India-WRIS system for nation-wide data storage and dissemination and the planned set-up of a National Water Informatics Center at MoWR, RD&GR are important steps forward towards institutional strengthening in the water sector. HIS champions emerged and new work protocols were institutionalized in several IAs. States strengthened in-house modeling capabilities and

obtained experience in sharing data and information in real-time. New states strengthened their field offices, built data processing centers and put HIS on the map as an important function of the water resources departments. Similarly, in states such as Gujarat, Karnataka, Maharashtra and Kerala, much was achieved in terms of impact on the general public through awareness programs and the media.

### *(c) Environmental and Social Impacts of the Project*

59. The Project aimed to improve the environmental knowledge base, environmental awareness, analyses of water quality and access to water-related information. It also aimed to develop analytical tools such as DSS systems and HDAs that, in addition to the improved knowledge base (PDS), are expected to better inform environmental activities and improve future environmental conditions in the Project area. In the long term, the strengthening of hydrological networks, knowledge base and analytical tools facilitated by the Project will contribute to better water resources engineering designs and related environmental assessments in the Project area. Project interventions and outcomes contributed to an overall improved and sustainable environmental management, through (i) generating a reliable and accessible hydrological knowledge base of meteorological, SW and GW resources and water quality data; (ii) promoting the use of hydrological models and analytical tools to mainstream environmental issues in water resources planning and management; (iii) water quality assessments; (iv) PDSs related to critical issues of environmental concerns in the water sector such as the pollution of SW and GW, water quality management and reservoir sedimentation; (v) aquifer mapping and GW management; and (vi) RTDSS systems. It is thus concluded that Project output will improve environmental management efforts rather sooner than later.

### *(d) Unintended Outcomes and Impacts*

60. The ICR mission observed that the majority of the IAs enhanced scientific outlook and analytical rigor in their functioning. The introduction of modern equipment and software, along with improved working environments boosted the morale and confidence levels of project staff and enhanced wider public acceptance of the data and information services provided by them. In many states, the HIS data helped agencies in clarifying questions raised by the legislatures as well as providing scientific evidence to the judiciary. An important outcome has also been a smoothened center-state relationship within the Indian federal system, where developmental projects prepared by the states are to be approved by the center for fund allocation. HIS provides a better rationalization of project designs and hence brings in more transparency in accepting as well as rejecting water sector projects submitted by the states to the center. The Project has been able to pierce through the veil of data ownership by the states and to introduce a culture of sharing historical and real-time data between the states and between center and states. This process was reinforced through the establishment of a new data dissemination policy by MoWR, RD&GR, which was operationalized through India-WRIS.

## 3.6 Summary of Findings of Beneficiary Survey and/or Stakeholder Workshops

61. Two national stakeholder workshops were held in New Delhi in January and June 2014 in which all HP-II agencies and some non-HP agencies participated. All HP agencies presented major achievements during HP, followed by sessions where several HP and non-HP agencies expressed their interests, needs and ideas for follow-up project interventions. The most important recommendation from the workshop participants was that the applications developed under HP-II need to be scaled-up for the entire country and thus extended to non-HP states. While project design would need to be

guided by the principles of IWRM, as spelled out in the National Water Policy (2012), this may also require providing institutional and technical support to newly emerging river basin organizations. Recommendations and suggestions for follow-up project interventions are summarized in Annex 6.

## 4. Assessment of Risk to Development Outcome

**Risk rating: Negligible to Low**

62. The overall risk to development outcome is assessed as *Negligible to Low,* based on the risk analysis summarized in Table 1.

**Table 1: Summary of Risk Analysis**

| Risk domain | Description of risk | Existing or Recommended Mitigation Measures | Risk Rating |
|---|---|---|---|
| RTDAS continuity | Equipment malfunctioning | • AMC has been entered into with the service providers for a period of 5 to 7 years along with 2 years' warranty. | Low to Moderate |
| Continuation of DSS | Software issues and continuity of trained staff | • Centralized licensing terms to provide for continued support and AMC<br>• NIH to provide regular training | Low to Moderate |
| Technical risks | Software (such as e-GEMS and e-SWIS) may not be completed and develop malfunctioning issues | • Database management software is centralized and web-based, and central agencies have long-term contracts for AMC with the providers | Moderate |
| Financial risks | Unavailability of funds for spill-over activities and AMC contracts may affect the sustainability of Project achievements | • All AIs have committed continued funding by allocating budgets<br>• Several activities have already been implemented using agencies' own resources<br>• Recurrent cost of meeting O&M, staff salaries and training plans are small compared to the regular budgets of IAs; low fiscal impact | Low |
| Performance of HIS | Continued performance of the HIS depends on internal and external demand for data | • Departments are active in creating public awareness on quality and quantity, creating external demands for data<br>• GW departments pursue community-based GW management<br>• Introduction of real-time data increased demand and use of HIS data and information in particular for flood and drought management<br>• DSS-P provided for basin-wide planning and resource management and can in future also serve useful monthly planning | Low to Moderate |
| Institutional risks | Inadequate capacity of HIS staff for continued management of HIS, reluctance to share data with the public and among agencies, lack of | • Ongoing training plans<br>• Recognition of a robust national HIS under the 12th FYP and the National Water Policy (2012) triggers establishment of a permanent | Moderate |

| Risk domain | Description of risk | Existing or Recommended Mitigation Measures | Risk Rating |
| --- | --- | --- | --- |
| | incentives to actually use HIS data and new tools for improved water resources planning, design and management, and the absence of a permanent central agency for continued coordination and management of HIS could affect the long-term sustainability and mainstreaming of HIS | HIS Cell and may trigger legislative changes regarding IWRM in India<br>• Hydro-meteorological Data Dissemination Policy of 2013 provides for free data sharing<br>• Web-based dissemination of data and information (WRIS) for the whole country<br>• These risks will be addressed in HP-III | |

*63.* At the time of the ICR, much had been achieved in terms of generating interest at decision making levels in MoWR, RD&GR and the participating states. The value of HIS data has become well recognized, RTDAS and RTDSS for flood forecasting and reservoir operation have proven their value and benefits, the 12th FYP assigns high priority to HIS/WRIS, and the interest of external data users is increasing. Meanwhile, MoWR, RD&GR and DEA have approached the Bank for the financing of an ambitious nation-wide phase III of the Hydrology Project, implying confidence in the HIS and Hydrology Project and its potential; hence, the rating is *Negligible to Low.*

## 5. Assessment of Bank and Borrower Performance

### 5.1 Bank

***(a)*** **Bank Performance in Ensuring Quality at Entry** (that is, performance through lending phase):

**Rating: Moderately Satisfactory**

64. *Strategic Relevance and Approach*: The Project was designed to have, and still has, an important and increasing strategic relevance for the water sector in India.

65. *Technical, Financial and Economic Aspects*: Project design was comprehensive and overall technically sound and allowed flexibility to adjust activities during implementation (see Section 2.1).

66. *Poverty, Gender and Social Development Aspects*: Project design adequately addressed environmental, poverty and social development aspects (see Section 3.5). The Project had significant indirect benefits in these domains. The project was correctly designed as a category “C” project.

67. *Fiduciary Aspects*: The Project’s financial management and procurement was designed around domestic procedures and was built on experience and systems evolved during HP-I.

68. *Policy and Institutional Aspects*: The design of the institutional component was (on purpose) kept rather light and did not raise substantial expectations toward IAs engendering substantive institutional changes.

69. *Implementation Arrangements*: Implementation arrangements were broadly similar to those that had been proven adequate during HP-I, albeit that PCS was supposed to be strengthened into a permanent HIS Cell with broader mandates and decision making powers than the present PCS. Project

design had insufficient teeth to ensure this institutional change, which did not yet take place. Readiness at Project launch was inadequate (see Sections 2.1 and 2.2). However, these factors have ultimately not prohibited a substantial, albeit delayed, Project outcome and PDO achievement.

70. *Monitoring and Evaluation Arrangements*: As elaborated in Section 2.3, M&L/E was conceptually well designed, but left its practical application open and the PAD did not provide well defined performance indicators.

71. *Risk Assessment:* Risk assessment has overall been adequate, despite long delays in Project effectiveness and unanticipated procurement procedures.

72. *Bank Inputs and Processes* during Project preparation have generally been adequate, with the QER panel providing substantive input towards improvement of Project design.

***(b)*** **Quality of Supervision and Support** (including fiduciary and safeguards policies)

**Rating: Moderately Satisfactory**

73. *Focus on development impact:* During the early stages of the Project, the quality of Bank support was less than satisfactory. Bank support could have been more proactive and supportive in expediting procurement and motivating state agencies to move ahead with crucial procurements. However, Bank implementation support has been of good quality since MTR. The Task Team focused on development impacts by providing support to critical strategic areas such as i) HIS data dissemination and utilization; ii) use of data for improving water resources management; and iii) the introduction of real-time data monitoring and DSS systems to support flood forecasting and reservoir operations. The Bank team has been flexible, accommodated timely restructurings and encouraged IAs throughout the Project period to adopt new technologies. The team promoted the inclusion of several additional activities and targets during and after MTR, thereby introducing novel technology to India's water sector.

74. *Supervision of fiduciary and safeguards aspect*: After MTR, the Task Team put much time and effort into procurement support and training, and support to improve fiduciary management. Since the Project was rated "C" regarding safeguard aspects, support in this domain required little attention.

75. *Adequacy of supervision inputs and processes*: The Bank missions had an adequate skill mix and were proactive in the identification and solution of potential issues. Regular implementation support missions were often followed up by short visits of country office staff to take stock of critical activities during key stages of development. The Task Team mobilized trust fund resources for special technical support, including resources from the Department of International Development (DFID) (US$1.5 million) and the Water Partnership Program (WPP), to bring in international technical and managerial expertise for capacity building and guidance of project teams. The Bank through country-based co-Task Team Leaders maintained a close, effective and constructive dialog with all IAs and MoWR, RD&GR, including the organization of several cross-learning and experience sharing workshops.

76. *The candor and quality of performance reporting* has overall been adequate and timely. The team ensured *adequate transition arrangements* after Project closure. All concerned IAs committed to the funding of spill-over activities, as well as the funding of AMC contracts and regular recurring cost

(staff, O&M, training). Preparations for the HP-III follow-up project had started in earnest at the time of completion of this ICR report.

77. *Results monitoring*: Efforts were largely focused on physical and financial input and output monitoring. An area where the Task Team could have focused greater attention is improvement of result indicators after MTR and outcome monitoring through a robust MIS and M&L/E system.

78. Overall, the Bank provided, particularly after MTR, strong technical, managerial and fiduciary support and has delivered a positive contribution to the outcome of the Project. After MTR, the Bank team continually encouraged IAs to expand their programs by adopting novel technologies and was flexible in adjusting and reallocating budgets across components within existing budget envelopes.

### *(c)* Justification of Rating for Overall Bank Performance

**Rating:** In view of the above analysis, overall Bank performance is rated as *moderately satisfactory*.

## 5.2 Borrower Performance

### (a) Government Performance: Moderately Satisfactory

79. *Positive Government ownership and commitment to achieving the PDO*: At the decision making level, MoWR, RD&GR has fully owned the Project and was committed to achieving its PDO during the second half of the Project. It has also developed: i) an ambitious and highly relevant Water Chapter for the $12^{th}$ FYP (2012-17) and a new National Water Policy (2012), which both put much emphasis on the need for HIS and IWRM at river basin scale; ii) an institutional benchmarking study for CGWB (with support of the Bank); iii) the India-WRIS; iv) proposals for the establishment of the National Water Informatics Centre; and v) a new Hydro-meteorological Data Dissemination Policy (2013), which recommends free of cost dissemination of non-classified hydro-meteorological data through India-WRIS. All these initiatives necessitate priority for the development of an adequate HIS or WRIS system for India and demonstrate continued interest in, and commitment to the Project from the decision making level in MoWR, RD&GR. However, project readiness at the time of negotiations and government ownership prior to MTR was inadequate. While the Project was negotiated in June 2004, Cabinet approval was only obtained in October 2005, followed by Project effectiveness on April 5, 2006, nearly 20 months after Board approval in August 2004. This time sequence flags less than satisfactory project management.

80. *Slow resolution of implementation issues, fiduciary aspects and M&E/L:* PCS was prompt in resolving technical matters and submitting routine reports, but has generally been slow in resolving implementation issues (particularly fiduciary issues), arranging critical consultancies, and posting sufficient qualified staff at the PCS (staffing levels have been lower than agreed at Project signature). The prolonged absence of the TAMC consultants from the time of the Project extension in 2012, insufficient technical assistance input in view of the institutional and technical complexity of the project and the large spread of the Project across 28 IAs, and long delays in obtaining the necessary approvals for procurements from PCS contributed further to delays in Project implementation. Despite these constraints, PCS has been able to provide during most of the Project period sustained leadership through continuity of a few key staff members. Fiduciary covenants have generally been complied with. Implementation of M&E/L has not been at par with Bank requirements.

81. *Stakeholder consultations*: The consultation of HDUG members varied largely across the IAs. Although consultations of data users have been less than expected in the PAD, the introduction of web-based data dissemination services by several agencies has, to some extent, compensated for this and has opened new avenues in India for the interaction with hydro-meteorological data users.

82. *Transition arrangements* have been adequate (see Section 2.5).

**(b) Implementing Agency or Agencies Performance: Moderately Satisfactory**

83. The performance of individual IAs is rated in Annex 2, considering such criteria as: i) agency commitment to and actual achievement of PDO, outcomes and target outputs; ii) data sharing and HDUG practices (stakeholder consultation); iii) adequacy of staff; iv) fiduciary and M&E aspects; and v) the adequacy of transition arrangements for the regular operation of Project supported activities after Project closing. Ratings were subsequently weighed based on the proportionate 2013 reallocations[11] of the Project budget, and a weighted average rating was assessed accordingly. The rating of individual IAs varies from Moderately Unsatisfactory to Highly Satisfactory, as shown in Table 2. Eight IAs scored highly satisfactory performance and seven IAs scored satisfactory or nearly satisfactory performance. These well performing IAs represent together 63 percent of total actual expenditures under the Project. Five IAs scored Moderately Unsatisfactory performance, representing together only 6 percent of the Project's expenditures. The remaining eight agencies, representing 31 percent of the project's expenditures, scored *Moderately Satisfactory* performance. Overall, state agencies scored better (on average *Satisfactory*) than central agencies (on average *Moderately Satisfactory*). The weighted average score of all IAs was *just below Satisfactory*.

**Table 2: Ratings of individual IAs**

| Highly Satisfactory (HS) | Satisfactory (S) to nearly S | Moderately Satisfactory (MS) | Moderately Unsatisfactory (MU) |
|---|---|---|---|
| BBMB | CPCB | CGWB | CWPRS |
| Andhra Pradesh-GW | NIH | CWC | Karnataka-GW |
| Goa | Karnataka-SW | PCS | Madhya P.-GW |
| Gujarat-SW | Kerala-SW | Andhra Pradesh.-SW | Odisha-SW |
| Gujarat-GW | Kerala-GW | Chhattisgarh-SW | Odisha-GW |
| Himachal P. | Puducherry | Chhattisgarh-GW | |
| Maharashtra-SW | Tamil Nadu | Madhya Pradesh-SW | |
| Maharashtra-GW | | Punjab | |
| **63% of total expenditures** | | **31% of expenditures** | **6% of expenditures** |

84. These ratings are based on final outcomes and do not take into account that there has been an initial lack of interest in the Project. The long pending approvals of procurements in EFC further eroded interest at agency level. It took until MTR (in 2009) for implementation progress to pick up speed, once TAMC was mobilized and interaction of PCS/MoWR, RD&GR with the states intensified. Most IAs tended to be slow in the resolution of implementation issues, with the exception of some

[11] Note that ratings were determined independently of financial outlays for each agency, but weighed on the basis of total allocated budgets.

proactive states like Gujarat, Goa, Himachal Pradesh and Maharashtra, and waited for PCS to provide approvals and resolve implementation issues. Satisfactory implementation progress thus requires strong leadership and project management by PCS, which will particularly also be required for the new states expected to participate in HP-III.

85. It is noteworthy that states with a combined SW and GW department appear to have performed better than states with separate departments. Important factors determining agency performance include *inter alia* cooperation and support from senior management and frequency of staff turnover. There is a strong correlation between agency performance and the importance assigned to HIS by the top management. In less performing states, there is often lack of staff motivation, inadequate staffing, lack of understanding and commitment to HIS by decision makers, and thus typically lack of priority assigned to the Project from management levels. States with excellent performance such as Himachal Pradesh, Maharashtra, Goa, Gujarat and Puducherry witnessed minimal turnover of key staff, while under-performing IAs such as Odisha (GW and SW) and Karnataka-GW experienced large staff turnover of staff and/or inadequate staffing.

### (c) Justification of Rating for Overall Borrower Performance

**Rating:** In view of the above analysis, overall Borrower Performance is rated Moderately Satisfactory.

## 6. Lessons Learned

86. Lessons and recommendations emerging from the implementation of the Project are as follows:

a) **For technically innovative and institutionally complex projects such as the establishment of HIS across India, a long-term programmatic and demand driven approach is required**, allowing each IA to progress at its own pace and evolving needs. A demand driven approach enhances the likelihood for support from top management and makes it more likely that outcomes will be achieved in a sustainable manner. Under future operations of this nature, it may be considered to offer IAs a balanced menu of project components, from which IAs can select options on a flexible need basis within broad budget allocations.

b) **Central agencies need to take a spearheading role regarding HIS data exchange and dissemination,** in order to accelerate the present paradigm shift towards river basin planning and IWRM in India. The scope of data and information collected under HIS needs to be expanded to reflect inter-sectoral interests in water and improve climate forecasts to enable improved flood forecasting and seasonal planning of agriculture and irrigation. The exchange platform between central and state agencies should be strengthened in order to promote the use of HIS data for IWRM and other purposes.

c) **Integration of SW and GW is required for adopting an IWRM approach at the state level:** Integration of state SW and GW departments and (particularly) State Data Centers facilitates and promotes the integration of SW and GW data analyses, enables the adoption of an IWRM approach at state level, and improves joint project management and implementation.

d) **Software solutions:** In the Indian context, it is generally preferable to adopt and adapt readily available third party software instead of developing new software from scratch, as has been the practice under the Project. Web-based data processing and storage systems facilitate easy accessibility across the country, central AMC and help desk functions, and reduce potential future licensing issues.

e) **Monitoring and Evaluation/Learning:** MIS systems for projects of the nature of HIS - which cannot be subjected to a classic economic and financial analysis - need to implement data-related value-addition studies as part of the M&E/L environment, by developing a benefit assessment mechanism for HIS-related activities.

## 7. Comments on Issues Raised by Borrower/IAs/Partners

(a) Borrower/IAs:

87. The response of MoWR, RD&GR to this ICRR highlights (see Annex 7) the many achievements of the project and notes the large number of IAs as well as Bank procurement procedures as major reasons for the initial delays in project implementation. Given the successful final outcome, rated as substantial in Section 3.2, the Borrower then proposes to upgrade the overall rating of the Project and of the Borrower, from *Moderately Satisfactory* to *Satisfactory*. While the end result of the Project reflects indeed a substantial achievement of project objectives and envisaged outcomes, the efficiency with which those results were obtained was only *Modest* due to long delays in Project effectiveness and initial start-up of the Project. As per the ICR Guidelines, the above ratings are thus not modified to satisfactory.

(b) Cofinanciers: N/A

(c) Other partners and stakeholders (for example, NGOs/private sector/civil society): N/A

## Annex 1. Project Costs and Financing

### (a) Project Cost by Component (in US$ million equivalent)

| Components | Appraisal Estimate (US$ million) | Actual /Latest Estimate (US$ million) | Percentage of Appraisal |
|---|---|---|---|
| 1. Institutional support | 43.09 | 45.41 | 105% |
| 2. Vertical extension | 50.99 | 32.53 | 63% |
| 3. Horizontal extension | 22.72 | 23.45 | 103% |
| Total Baseline Cost | 116.80 | 101.39 | 87% |
| Physical Contingencies | 7.71 | 6.70 | 87% |
| Price Contingencies | 10.54 | 9.16 | 87% |
| Total Project Costs | 135.05 | 117.25 | 87% |
| Project Preparation Facility (PPF) | 0.00 | 0.00 | 0.00% |
| Front-end fee (IBRD only) | 0.524 | 0.524 | 100% |
| Total Financing Required | 135.574 | 117.77 | 87% |

### (b) Financing

| Source of Funds | Type of Financing | Appraisal Estimate (US$ million) | Actual/Latest Estimate (US$ million) | Percentage of Appraisal |
|---|---|---|---|---|
| [Government] | | 30.594 | 26.19 | 87% |
| [IBRD/IDA or GEF] | | 104.980 | 91.58 | 87% |

## Annex 2: Outputs by Component

1. The main components of HP-II are (1) Institutional strengthening, covering all participating 13 states and eight central agencies; (2) vertical extension, covering the nine existing HP-I states and eight central agencies including two new central agencies (CPCB and BBMB); and (3) horizontal expansion, covering four new states. This Annex describes the Project's main achievements with state wise results listed in Table A3.

### Component 1: Institutional strengthening – moving from manual to automatic data collection and from desktop to web-based data processing and storage

2. The institutional strengthening component provided for: (i) the consolidation of HP-I activities in the HP-I states and central agencies, including upgrading of hardware and software; (ii) support for the strengthening of HIS awareness, and for data and knowledge dissemination and sharing in all IAs; and (iii) technical and management assistance to all IAs and PCS for implementation support. HP-I states were encouraged to modernize their existing systems by using real-time data acquisition and telemetry technology to transmit hydro-meteorological data in real time to centralized locations. Accordingly, most HP-I states witnessed a transition from manual to real-time data acquisition systems and from desktop to web-based software applications.

#### Sub-component 1.1: Consolidation and upgrading of HP-I achievements

3. The consolidation and upgrading of HP-I achievements focused on the strengthening of the capacities of the IAs in HP-I states and central agencies to use existing hardware, software and equipment on a sustained basis. The physical and financial sustainability of the operation and management of the hydrological networks and instrumentation established under HP-I was to be supported through (i) upgrading the hardware, software, hydrometric equipment and network capacity; (ii) procurement of spatial data sets; (iii) further development of (geo) hydrological data processing and storage systems; and (iv) improving the related capacities at agency levels (training).

4. **Upgrading of strengthening of monitoring networks: moving from manual to automatic data acquisition:** Monitoring networks in HP-I states and central agencies have been strengthened through (i) consolidation and expansion of monitoring networks for rain gauges and meteorological stations, reservoir and river gauging and discharge stations, GW observation wells and piezometers with Digital Water Level Readers (DWLRs); (ii) replacement and upgrading of existing (HP-I) equipment, water quality laboratories, computer infrastructure and data centers; and (iii) addition of automatic data acquisition equipment, such as radar type water level recorders for rivers and reservoirs, automatic snow gauges, automatic weather stations (AWSs), Acoustic Doppler Current Profilers (ADCP), automatic rain gauges (ARG), additional DWLRs for GW observation wells, and water quality sensors in rivers. The planned upgrading and strengthening of the existing and new monitoring networks was substantially completed at Project closure, and some agencies (for example, Andhra Pradesh-GW, Gujarat-GW, Maharashtra-SW and Tamil Nadu) went well beyond their initial PAD/PIP project targets. Odisha and Gujarat added a large number of GW observation wells and piezometers to their monitoring networks. HP-I agencies have generally not extended their configuration of offices and data centers at state, division and sub-division levels. A number of monitoring stations have been equipped with real-time monitoring and transmission equipment (telemetry) for managing reservoirs,

GW abstractions, flood control, irrigation diversions and droughts. One precondition for the funding of real-time reporting stations was that the IAs would have to commit that the real-time data would be made available to data users through a website. The available HP-I technical specifications for equipment, structures, software and other items needed for the HIS monitoring networks and data processing systems were upgraded and approved by the Hydrological Information System Management Group (HISMG)-Tech, and are available on the internet (www.hydrology-project.gov.in) for general use. To improve the quality and reliability of the procured equipment, bid documents required extended warranty periods (at least two years) and a minimum of three years of comprehensive AMC following the warranty period; the cost of AMC was included in the bid evaluation.

5. **Staffing and O&M budgets:** Annual O&M budgets vary considerably across IAs, from less than US$10,000/year in Chhattisgarh, Madhya Pradesh and Odisha to US$300,000/year in Maharashtra-SW. HIS O&M functions are generally staffed by regular departmental staff and funded from the regular budgets. Overall, staffing and O&M budgets have not raised significant issues under HP-II. In Karnataka-GW, most HIS staff was transferred mid-way through the Project, which severely affected implementation progress and performance in this department.

6. **Water quality data collection and management:** HP-II focused on four major issues regarding water quality data collection and management, including i) consolidation and upgrading of HP-I laboratories; ii) development of laboratory facilities in the four new states; iii) support to development activities by CPCB; and iv) training arrangements for laboratory staff. Several States including Maharashtra, Andhra Pradesh and Madhya Pradesh (Table A.3) have been maintaining level 2 and level 2+ labs. The state of Maharashtra has been successfully maintaining labs under public-private partnership arrangement. Further, project pioneered in the introduction of real time water quality station that were introduced by CPCB and CWC in Ganga (10 Stations) and Yamuna (3) rivers respectively and are being shared by CPCB on web (for details refer section para 39 below).

7. **Upgrading of software - moving from desktop to web-based software applications:** After MTR, new software were developed to modernize the HIS and convert desktop-based data entry, processing, storage and dissemination systems into centralized web-based systems, with the aim to centralize O&M and AMC, and reduce the burden on state agencies, particularly:

- **e-SWIS for SW**: Integration and upgrading of the existing desktop based (HP-I) software systems to the web-based by CWC;
- **e-GEMS for GW:** Upgrading of the existing GEMS to the web-based by CGWB; and
- **e-WQIS for Water quality**: Development of a Geographical Information System (GIS)-based web portal for water quality data and information by CPCB.

8. **e-SWIS:** The objective of the e-SWIS system of CWC is to introduce a web-based hydrological information system, which can be used by state agencies (including non-HP IAs) without any infrastructure requirement but computer equipped with the internet. Key design aims have been to retain the familiar HP-I software environments, minimize licensing costs for end users, develop an open modular framework to allow for future expansion, and make the system capable of handling data from new technology sensors. The database and applications are hosted on commercial cloud servers, with all HIS data being held in a single database, but with access controls retained by the agency 'owning' the data. The e-SWIS system provides the necessary facilities for web-based data sharing and

dissemination, and is intended to become the central repository of SW-related data. During the 2014 monsoon season, CWC used e-SWIS to disseminate (eSWIS-MapViewer) real-time flood levels across India including for classified basins. The contract for development of e-SWIS was only signed in December 2012 and development was substantially completed at Project closure. Testing and validation of the software system has been completed in November 2014, to be followed by the roll-out of the system (with training) to all HP states and regional offices of CWC. The late completion of this activity was caused primarily by its late start well after MTR (it was not planned at PAD stage). For sustainability reasons, the contract for e-SWIS includes a warranty period of three years, followed by an AMC period of seven years. CWC has allocated adequate funds for financing the spill-over of the software development, the roll-out of the system, training for CWC and other SW agencies, and AMC.

9. **e-GEMS:** The objective of the web-based e-GEMS system of CGWB is to create an internet-based central repository and data processing tool for GW-related data (such as water level, water quality, exploration, geophysics and GIS data). It replicates the functionalities of the previous GEMS system, under a much enhanced and integrated system design, and incorporating more than six years of experience with the previous system. Users in state and regional GW agencies will be able to enter and process data online and within their own virtual data repositories, without requiring specialized software and hardware. Sharing of data between agencies is facilitated as per the existing guidelines for data sharing. The system is centrally developed and maintained by CGWB, thus ensuring uniformity in GW-HIS procedures across HP states and CGWB regions, central maintenance and central data storage.

10. Development of e-GEMS commenced only in 2013, after a protracted tendering exercise. At Project closure, majority of modules were completed for pilot testing, but many activities remain incomplete, including: deployment of software for pilot testing (completed in October); migration of existing data from HP-I systems to the new e-GEMS database; full scale roll-out of the software (expected by February 2015); documentation and online help; capacity building; leasing of servers; and helpdesk and support services. The e-GEMS development contract includes a one-year warranty and four- year AMC. The late completion of this activity was caused primarily by its very late start in 2013 and delays in the procurement of software licenses and server systems by CGWB. CGWB has proposed to MoWR, RD&GR that remaining activities and procurements required for the development and deployment of e-GEMS be completed through its "mother scheme", the Ground Water Management & Regulation Scheme. CGWB intends to introduce e-GEMS in due time also to non-HP state GW agencies and to all its regions. CGWB will need to expand its own capabilities to ensure that users, especially outside CGWB, feel fully supported in their use of the system, and that future upgrades are effectively managed.

11. ***GIS-based web portal for water quality data Water Quality Information System (e-WQIS):*** Both e-SWIS and e-GEMS incorporate modules for the entry of water quality data, and these systems are expected to replace current software used within the SW and GW water quality laboratories. Data on (mostly) SW quality measurements regarding pollution is dealt with by CPCB, which has focused on systems for improving the accessibility of data to end users and for the general public. This includes the development of a system for publishing real-time water quality data from automated river water quality stations; e-WQIS is a GIS-based web portal for water quality data that allows users to receive data summaries and review historical measurements across the full set of CPCB/SPCB measuring locations. CPCB awarded the contract for development of e-WQIS late 2013, including three years of AMC. The bulk of software development has been completed, and hardware and software have been

purchased for installation in the CPCB offices. The system has been opened to the public for a limited set of river basins; further river basins will be added as data validation is completed. The system is expected to be fully online by December 2014. It constitutes a major step towards making water quality data available to the public at large across India. CPCB has committed funding for completion of its e-WQIS web portal.

**Sub-component 1.2: Awareness raising, data dissemination and knowledge sharing**

12. ***Information dissemination:*** All agencies have prepared websites to disseminate information about HP/HIS and share meta-data regarding the available historical hydro-meteorological and GW data. Some agencies are also sharing real-time hydro-meteorological data on their websites, which the Bank had wisely made mandatory for agreeing to the funding of RTDAS. Gujarat-SW, Himachal Pradesh, Karnataka-SW, Maharashtra-SW & GW, Puducherry and Tamil Nadu reported that authorized users can download HIS data directly through the internet. PCS has maintained the central HIS website with HP design documents and manuals, and current news and events.

13. ***Hydrological Data User Groups:*** The project has transitioned through registered data users (HDUGs) to web-based data system opening to public or registered users. Several agencies are now sharing the data on the web with public. Therefore, membership of HDUGs varies significantly from state to state; HDUGs are functional and conduct at least annual meetings for nearly all agencies. Andhra Pradesh (GW), Gujarat and Kerala (GW) exceeded the minimum target (once per year) by organizing many district level HDUG meetings. All HP IAs provide HIS data to outside entities, varying from 10 to 100 data requests per year. Most agencies systematically document HIS data use. User satisfaction is generally not surveyed, but the response time is reported to be one to two weeks. Overall, states claim regular interactions with data users, and HIS data are increasingly used to address actual problems and data needs, both within government departments and in the society at large (see Annex 3). Hydrological Information Needs (HIN) assessments were not systematically conducted, other than that MoWR, RD&GR constituted a Task Force with the objective of assessing stakeholder data needs. Principal findings were: i) hydrologic data are used for a very diverse range of activities; ii) data users include academicians, planning and development specialists, consultants, industrial and commercial decision makers, social workers and advocacy activists, and “concerned citizens”; iii) data requirements include daily river flow data, monthly GW data, water quality data for rivers and aquifers, sediment data, aquifer hydraulic parameters and river morphology data; and iv) generally data users encounter difficulties in obtaining access to data. These findings have guided the development of MoWR, RD&GR’s new Hydro-meteorological Data Dissemination Policy (2013) and the development of India-WRIS, discussed further below; both aim to make hydro-meteorological data more accessible to data users. Maharashtra-SW has successfully pioneered the assessment of a broad based HIN survey.

14. **Awareness raising:** TAMC developed a framework to guide activities for raising awareness on the HIS, and to focus on the understanding of user information needs. A series of HIS awareness raising workshops were conducted on a regional basis and a manual was developed and shared with all agencies to take the HIS promotion activities forward. Some specific visual tools (posters, brochures, pamphlets) were also designed and shared with all agencies for reproduction and distribution. Andhra Pradesh-GW, Maharashtra and Gujarat took full advantage of these tools and excelled in this domain, but most agencies showed lack of enthusiasm. Overall, GW departments have performed more awareness raising activities than SW departments, likely due to the importance of GW for domestic

water supply and minor irrigation in rural communities. Awareness activities were mainly connected to GW availability, over-exploitation, water quality, recharge, rainwater harvesting, and so on. New states have been slow in initiating these activities, since it took most of the project period to create a functioning and 'demonstrable' HIS in their state. Overall, it appears that awareness raising regarding water issues and HIS has not attracted the attention of the IAs it deserves. Thus, important opportunities to increase public awareness in India about water issues and the value of HIS were missed. Future awareness raising activities should not only focus on water issues, but also on demonstrating the value of HIS and creating a demand for HIS data.

15. ***Data sharing and dissemination policy:*** In May 2013, MoWR, RD&GR issued its Hydro-meteorological Data Dissemination Policy under GoI's National Data Sharing and Accessibility Policy of GoI (2012, NDSAP: *http://wrmin.nic.in/writereaddata/linkimages/hddp4302748422.pdf),* which advises the following for unclassified data: "All unclassified data shall be hosted on the India-WRIS website *(www.india-wris.nrsc.gov.in),* which can be downloaded by any web-registered user free of cost". Data for national rivers are unclassified. Whereas the data for international rivers remain classified, it is significant that certain data for these basins are also non-classified, including reservoir levels, live storage positions, water quality, and all GW (http://gis2.nic.in/cgwb/Gemsdata) and meteorological data. Similarly, all meta-data are non-classified, including annual averages and important historical data (such as highest flood levels, yearly flood peaks, and so on). The new data sharing policy is generally appreciated as a major breakthrough. However, it covers only two constituents, CWC and CGWB, and does not cover the most important repository of meteorological data with IMD, which has a much larger network of data collection. Several HP states are also still charging a fee for their data. MoWR, RD&GR has advised states to update their data sharing policy in conformity with its national data sharing policy and share their water data through web-based systems with the public and stakeholders free of cost, in order to encourage the use of these data for enhanced water resources management and planning. Some states have already started sharing data on web and some are working on revising the data dissemination policy in line with MoWR, RD&GR's.

16. ***Data dissemination:*** To implement the new data dissemination policy, CWC has developed – in a joint venture with the ISRO – the web-based water resources information system (India-WRIS web-GIS; *www.india-wris.nrsc.gov.in),* to enable the sharing of spatial-temporal data. The portal aims to provide a single window solution for making available comprehensive and consistent data and information on India's water resources and allied natural resources, in a standardized national GIS framework and with tools to search, access, visualize, understand and analyze the available data for water resources assessment, monitoring, planning and development. The portal contains about 100 spatial data layers and temporal data for periods spanning five to 100 years and intends to introduce state chapters for exchange of information.

17. The number of data requests reported by IAs varies largely, generally between 10 and 20 requests per year (see Annex 3), with the exception of Gujarat, Tamil Nadu and Maharashtra. Maharashtra (SW) registered, since 2006, about 900 data requests for a total of 80,000 station years of SW data, generating INR 10 million and including 220 data request for academic and scientific use. Maharashtra (GW) has 577 registered data users and generated INR 2.9 million through data dissemination (data are free for research purposes). Gujarat (SW) recorded about 90 data requests per year and Gujarat (GW) 50 data requests per year, while Tamil Nadu (SW + GW) registered 300 data requests over the project period. Himachal Pradesh signed an MoU for the (two-ways) sharing of HIS data for improved coordination and optimization of sustainable hydropower development in the Sutlej

basin with twelve power developers and other relevant stakeholders, including BBMB. The SW data demands are mainly from government users and large scale private sector users such as the national and state disaster management centers, water resources planners, agriculture departments, public works departments, universities, industries, consultants and municipal corporations. SW data were predominantly acquired for design purposes (structures, schemes, roads, flood levels, etc.) and research, as well as for the assessment of hydropower potential, irrigation management, water disputes and the settlement of insurance claims. The GW agencies, on the other hand, extend their services to a completely different set of data users. They mainly constitute researchers, NGOs, national banks that fund agricultural activities, real estate developers and farmers. The most common GW data demand is for water level data of observation wells and piezometers, GW assessment data and stages of GW development at taluka (sub-district) and sub-basin levels; data on GW quality are also sought by many GW data users.

18. ***Inter-agency data sharing and validation:*** Most state GW agencies reported that data sharing for inter-agency data validation and GW assessments is ongoing satisfactorily with CGWB. SW agencies generally report that CWC is slow or non-responsive regarding validation of the SW data sent by the states. IMD is more responsive regarding data validation of meteorological data, though its process is sub-optimal and time consuming. Clearly, inter-agency data validation remains important in view of inter-state water issues, overall data quality control and maintaining uniformity in data collection practices and standards across the country. Moreover, CWC reviews the detailed project report for major irrigation projects prepared by states which highly rely on HIS, and therefore it would help expedite the preparation and approval of detailed project reports if states already had validated data. CWC should step up to its responsibility for inter-agency data validation as soon as possible. The e-SWIS system may facilitate this process in due time.

**Sub-component 1.3: Implementation support**

19. Implementation support was to strengthen project coordination and management through the provision of technical and management assistance and technical consultancies, including studies, workshops and training. Under this sub-component, IAs also strengthened and upgraded their office infrastructure (including a new State Data Center for Andhra Pradesh-GW), vehicles and office equipment.

20. ***Project coordination:*** The Project was established with a National Level Steering Committee (NLSC) chaired by the Secretary of MoWR, RD&GR, with three "Hydrological Information System Management Group" (HISMG) sub-committees, notably i) Technical (HISMG-Tech); ii) Institutional Strengthening and Training (HISMG-IS&T); and iii) Data Dissemination (HISMG-DD). Additionally, the Specifications Committee undertook reviews and approval of technical specifications for equipment to be procured under the project. The sub-committees met irregularly on a need-basis, while the NLSC met on a regular basis in the early part of the project to drive the Project forward.

21. ***Technical Assistance (TA):*** Whereas the Terms of Reference (TOR) for TAMC put much emphasis on the "added value" of using international consultancy to provide advice and guidance for institutional development and technical leadership, PCS focused the actual TA provided mainly on project management assistance regarding i) procurement, bidding documents and bidding processes; ii) financial reporting, auditing and financial management issues; iii) progress reporting and awareness-raising initiatives including website development; iv) assisting individual IAs on equipment

specifications, bid evaluations and finalization of contracts; and v) the technical review of other consultancies under the Project. Much of the resources available to TAMC were diverted to active support of PCS in areas of procurement and financial management that were originally not planned to be key areas of TAMC support. The staffing at TAMC was not matched with the changed scenario after MTR which required technical support more intensely. This has led to a significant change in the inputs of experts within the TAMC team, especially the upgrading of inputs of procurement and financial management specialists (each to over 40 staff months) in the team. Thus, in the end, TAMC provided mostly management and implementation consultancy and insufficient TA per se. The international water sector MIS specialist was also not fielded and developed MIS once, was and did not further continue to update the program and monitor outputs, which caused M&L/E under the Project to be inadequate, in particular the outcome and results monitoring. In new projects of similar institutionally and technically complex nature, conditionalities regarding the provision of adequate TA input and timely recruitment of TAMC type consultants need to be included in the project readiness process.

22. ***Technical consultancies:*** Besides TAMC, a number of large technical consultancy contracts have been awarded under the Project, including for: i) DSS-P, managed by NIH; ii) RTDSS developments managed by BBMB and Maharashtra-SW; iii) SW-HDA and e-SWIS development managed by CWC; iv) e-GEMS development managed by CGWB; v) development of e-WQIS by CPCB; and vi) pilot aquifer mapping projects managed by CGWB. Most consultancy activities are completed successfully or will be completed by the end of 2014, with exception of the contract for HDA development. Consultants will provide AMC for several years to come for software products and systems, varying between four and seven years. The ICR mission noted that there is scope for enhancing the interactions between clients and consultant teams for transfer of knowledge and obtaining the maximum possible outcome from and efficiency of the consultancies, and approaching the consultancy process as a partnership. Moreover, TORs should leave sufficient scope for flexibility to make adjustments to contracts in order to achieve maximum benefits from a consultancy.

23. **Technical assistance provided by the World Bank sharing global best practices:** Grants from Bank funds and bilateral sources have played a major role in bringing about successes of HP. During HP-I, a grant of €14.56 million was provided by the Government of the Netherlands, which supported TA for setting up a strong foundation of HIS for India. This TA was not financially controlled by MoWR, RD&GR and allowed a large flexibility in its implementation, for the benefit of the Project. During HP-II, MoWR, RD&GR engaged the TAMC consultants (for a budget of only US$3 million). Although time based, the flexibility in the consultancy was limited. The resources planned for TAMC were not sufficient to meet the demands of the IAs and were not able to match the changing needs of the Project. In particular, after MTR, when the Project transitioned to adopting the latest monitoring technology and aquifer mapping techniques, the required expertise could not be made available through TAMC. Therefore, the Bank's support team made extra efforts to arrange additional funds for organizing technical support and expose the clients to the latest global practices, primarily funded through trust funds. These included a DIFD-TF (US$1.5 million), WPP and other support. These trust funds served well as catalyst for the success of the Project. The Bank contributed particularly through the following activities:

- The Head of the National Water Agency (ANA) in Brazil shared information on the data management and reservoir operation systems in Brazil and why ANA opted to make data accessible to the public;

- Experts shared experiences with the evolution of the meteorological forecast set-up in the USA, conducted training sessions to expose IAs to flood forecasting systems, and supported agencies with the design of RTDAS;
- USGS experts were arranged to share their experiences in aquifer mapping. Thereafter, Ministry officials visited USGS and MoWR, RD&GR intends to arrange cooperation with USGS;
- Multiple stakeholder workshops were arranged to share and exchange experiences and lessons learned between various agencies; and
- Benchmarking studies were undertaken by international experts for research institutes, exposing them to international best practices and recommending reforms and required infrastructures.

24. **Training:** Early on in the Project a training framework was established and training coordinators were appointed. Central agencies conducted a pivotal role in providing a variety of training courses, including Training-of-Trainer (ToT) courses, with the ultimate objective to: i) enable all HIS staff members in achieving full proficiency in all aspects of HIS data management; ii) upgrade DSS and PDS proficiency amongst HIS staff; iii) build data collection, processing, management and dissemination skills of all IAs, especially new HP states; and iv) build skills and attitudes of staff to stimulate HIS data dissemination. Training courses covered a gamut of topics, including:

- Technical: Analysis of high frequency DWLR data, ADCP, various software, DSS-P, water quality analysis, geo-informatics, telemetry, data processing, HDA, RTDAS and RTDSS;
- Operations: Drought management, O&M protocols, awareness training, HIS data center management, remote sensing and GIS, water quality management and statistics in hydrology; and
- Management: Management processes, leadership skills, HIN and HIS, presentation and report writing skills, and World Bank procurement procedures.

25. Most agencies reported (i) a significant number of trainings conducted under HP-II; (ii) the availability of in-house trainers; and (iii) the regular approval of annual training programs and budgets. Nonetheless, there is a need to stimulate the utilization of more training opportunities by all IAs, to improve the coordination between central training providers and state IAs, and to encourage the continuation of domestic study tours (inter-agency visits). Institutional memory is often lost due to frequent transfer of staff and repeated basic HIS training is needed to overcome this constraint. Like under HP-I, conditionality for participation in international training programs should have been imposed, requiring that participants must remain involved in the Project for at least three years after an international study tour. The potential of web-based learning opportunities and Massive Open Online Courses should be explored by institutes such as NIH, CWPRS, Indian Institutes of Technology, and so on in future.

26. **Organizational development and institutional strengthening:** At the national/central level, in parallel to HP, there have been a number of positive developments within MoWR, RD&GR towards institutional change and creating a necessary sustainable national WRIS, including (i) development India-WRIS developed by CWC and ISRO as a broad vehicle for data dissemination through the internet; (ii) development of a Ground Water Information System (GWIS) for free data retrieval of CGWB data through the internet; (iii) the finalization in 2013 of a new Hydro-meteorological Data

Dissemination Policy of MoWR, RD&GR, using the vehicles of the India-WRIS and GWIS for public access to data; (iv) the proposed establishment of the National Water Informatics Center in CWC as the seat for HIS management functions and the host of India-WRIS; and (v) reviews of institutional responsibilities carried out under Bank managed benchmarking studies.

27. At the agency level, TAMC performed, initially, a culture survey to enable guidance of the IAs regarding their transition to sustainable institutions and change management. The major issues emerging were similar to those encountered under HP-I, *inter alia:* i) inadequate HIS staffing; ii) insufficient coordination and collaboration between different agencies implementing HIS; iii) rigid activity and spending orientation and inadequate results focus; iv) inadequate connectivity with HIS data users; v) insufficient latitude for the HIS wings; and vi) lack of understanding and commitment to the HIS by decision makers. Subsequently, a number of tasks to enable the transition to sustainable institutions and to manage such change were started. However, IAs showed little interest in this issue and PCS shifted priorities for TAMC input to other domains. Most of the institutional strengthening tasks envisaged were 'soft' and 'untested' in nature, and therefore were considered too early to introduce. For example, the current institutional arrangement for HIS is considered as structurally sound by PCS and IAs, and revising them to promote the use of HIS was considered too radical.

28. TAMC engaged in a number of dialogs to identify the level of interest in developing sustainable institutions as part of HP, and to identify key controllers of change within the central partner institutions. The net result was that developing a road map, leading to setting up an agency for managing a WRIS and determining its role, structure and staffing at the central and state level was considered premature at this stage. Therefore, little progress has been made regarding institutional strengthening for HIS, and this aspect will need focused attention during any follow-up operation. At the agency level, institutional support has thus not attracted the attention it deserved, made evident by the absence of AQC programs for water quality laboratories, inadequate inter-agency data validation, inadequate M&L/E (focused mainly on procurements and inputs), the lack of involvement of TAMC consultants with HIS data processing and storage, the absence of HIN assessments, and the absence of a post-Project roadmap for HIS sustainability (including post-Project staffing, O&M budgets and training plans). It would thus be desirable to incorporate conditionality regarding institutional change in the negotiation and readiness process of any follow-up operation.

**Monitoring and Learning/Evaluation: See Section 2.3 of this ICR**

**Financial Management and Procurement Support: See Section 2.4 of this ICR**

**Component 2: Vertical Extension – Moving from Information to Application**

29. The objective of Component 2 was to support HP-I agencies in moving from information to application, that is, to move from development of HIS towards the enhanced and effective use of the HIS data repository in water resources planning and management, and to demonstrate useful hydrological data applications for future replication. Sub-components included initially i) development of HDAs; ii) development of DSS-P in all HP-I states; iii) development of RTDSS systems for flood forecasting and real-time reservoir operations in the Bhakra-Beas and Mahanadi Basins; and (iv) implementation of a range of PDS. The scope of this component was significantly extended after MTR by introducing RTDAS in eleven more states, for automatic weather stations and rain gauges, river and reservoir water level sensors, and GW levels, to enable improved flood forecasting and reservoir

management, as well as drought management. Pilot studies for enhanced aquifer mapping have also been introduced.

**Sub-component 2.1: Development of HDA**

30. The development of HDAs promotes the use of HIS data for the standardization of hydrological design practices across India in the SW, GW and water quality domains, using well established nationally and internationally accepted methodologies in a user-friendly environment. For the GW domain, it was decided to include HDAs in the newly developed e-GEMS system, including GW quality. CPCB has addressed the need for providing guidance in the use of water quality data by commissioning the preparation of a report on water quality assessment, to be made widely available as a guidance document. CPCB intends to enhance public access to water quality data under the National Data Sharing and Accessibility Policy (NDSAP, 2012) through the development of a web-based GIS enabled data system (e-WQIS; see Section 1.2) for all water quality data available with CPCB. These activities will only mature after Project closure, but demonstrate, nonetheless, how fast the era of data secrecy is changing in India.

31. For the SW domain, spearheaded by CWC, these design aids are intended to i) facilitate and expedite water resources availability and yield assessments (HDA-Y); ii) improve the hydrological design of infrastructure and estimation of design floods for gauged and ungauged catchments (HDA-F); and iii) improve reservoir sedimentation analyses and sediment management (HDA-S), with the objective to standardize hydrological analyses and consolidate design practices in India through uniform approaches across states and central agencies. The contract, awarded in November 2009, includes an AMC for the years. Despite contributions of TAMC consultants and Bank support missions, the HDA project component for SW has been poorly implemented and faced many delays due to the initial underperformance of the HDA consultants. Consequently, the HDA tools, data base and GIS platform were completely redesigned and revamped in 2013. The HDA-Y module for water resources assessments could not be satisfactorily completed before Project closing, while the HDA-F and HDA-S modules were still under testing by CWC. Few opportunities were taken to test and validate the standard HDA methods with available HIS data collected and stored by the states. The training of staff of CWC regional offices (including T-o-T training) is still to be completed. The intended roll-out and pilot applications of the HDA system to/in HP and non-HP states is pending the completion of the tool by February 2015. CWC has yet to develop a post-Project plan for introducing the HDA to HP as well as non-HP state agencies. CWC has committed sufficient funding for post-Project completion of this project component. The Chairman of CWC expressed his full commitment to complete and sustain the HDA package, seeing this tool as essential for the way CWC would function in the future.

**Sub-component 2.2: Development of DSS**

**a) Use of GIS**

32. Many IAs acquired ArcGIS software under the Project directly from ESRI-India as single source supplier at specially negotiated rates, and have used it to display information and prepare reports within the project. Agencies have also continued to procure geospatial data-sets as mapping layers for use within the GIS. This has been particularly beneficial for DSS-P work.

**b) Development of DSS-P Systems for Water Resources Planning and Management**

33. Under the aegis of NIH, DSS–P systems for integrated water resources planning, development and management were developed for 13 river basins in the nine HP-I states. The modules included in DSS-P concern SW planning; GW use planning; integrated reservoir operations; irrigation management; drought monitoring, assessment and management; planning of conjunctive use of surface and GW; and management of surface water and GW water quality. Across the nine HP-I states, eleven DSS-P systems have been completed, including a Final Report; work on two basins in Tamil Nadu was still ongoing at Project closure. Key functionalities of the DSS-P are comprehensive information management, simulation of river basin hydrologic processes, and scenario analysis and management. The DSS-P modeling framework includes (i) a dashboard to display, analyze, and test various water use and development scenarios in GIS and tabular platforms; (ii) proprietary rainfall – runoff and river basin simulation software; (iii) a GIS platform for spatial data analysis; and (iv) tools for time series data analysis. The dashboard is license free, but the models require licensing. States have in place the required hardware and software systems, a functioning database, a calibrated river basin modeling system, customized models and example scenarios. Staff has been trained and the general capability of the IAs has been developed. The DSS-P software is installed on a server at NIH for easy access by current and future new users. NIH has developed the website www.NIH-DSS-Planning to disseminate information regarding the DSS-P. The DSS-P project component has generated interesting and useful results, such as recommendations for water resources department interventions, drought management, seasonal planning of (integrated) reservoir operations and flood management, benefits of changing cropping patterns, conjunctive use of SW and GW along with artificial recharge, and sustainable GW management.

34. **DSS-P sustainability:** Kerala has championed DSS-P applications through 17 applications and plans to apply DSS-P to 20 river basins in the state as per the special direction of the Additional Chief Secretary, Government of Kerala. Kerala ultimately intends to cover the entire state with DSS-P models. Replication of the DSS-P is also ongoing in Gujarat. To enhance the utility of DSS systems for water resources planning and management, the ICR mission recommends that, where not yet practiced, the connection between staff at the data centers and field staff be improved. The planning departments of the state water resources departments should also be included in these activities in view of their potential strong interest in these systems, which may further its sustainability. States need to be encouraged to adopt DSS-P as a key tool for IWRM and water resources department planning. Sustainability of this component further requires continued staff training in a high staff turnover environment, updating of DSS skill sets, creating intra-agency as well as external awareness about the DSS capabilities, and expansion of DSS-P to other basins in the various states. It is crucial that adequate support is provided to the IAs regarding further applications of DSS-P and its embedded software systems. NIH should appraise the needs of the states for continued support.

**c) RTDSS and RTDAS: Moving from Manual to Automated Data Collection in Real-time**

35. **RTDAS and RTDSS system for Bhakra-Beas Basin:** Initially the project only planned the piloting by BBMB of RTDSS and RTDAS for flood management and advanced reservoir operation for the Bhakra-Beas River system (and a RTDAS for the Mahanadi basin). BBMB has a well-defined need for RTDSS with respect to managing the water resources in the Sutlej and Beas Basins. The RTDSS supports decisions on reservoir operations to meet multiple objectives, for example, managing spills and reservoir storage to optimize hydropower generation, managing flood risks and meeting the

irrigation and municipal demands of downstream users. The system would support operational decisions requiring hydrological information at daily or even shorter time intervals, including decisions related to the scheduling of reservoir releases and hydropower turbines, flood management, flood warnings and disaster management. The development of the RTDSS included (i) the commissioning of a RTDAS for the basin including 91 real-time reporting monitoring stations (weather stations, rain gauges, water level recorders, and nine snow stations in a high altitude snowmelt region); (ii) cross-section surveys of the major rivers and tributaries; and (iii) the development of a flood forecasting and reservoir operation modeling system, including hydrologic and hydrodynamic modeling. The RTDSS is expected to improve dry season water management of the Bhakra (Sutlej River) and Pong (Beas River) Reservoirs, and thereby improve water supply conditions in Punjab, Haryana and Rajasthan, and reduce downstream flood disasters, particularly at the end of the monsoon season. BBMB has substantially completed its RTDSS project component. The large majority of the RTDAS is commissioned and provides real-time data every 15 minutes. Due to severe logistic constraints, some of the snow stations in the Upper Sutlej catchment remained to be completed after Project closure, during the 2014 summer season. The RTDSS modeling system has been run for final calibration and testing during the 2014 snowmelt and monsoon seasons (April-September 2014) and has been used successfully for reservoir operation.

36. BBMB intends to extend the RTDAS downstream of Bhakra Dam, to help in optimizing the distribution and utilization of the available water among the riparian states. BBMB has committed adequate funding for the spill-over activities and future AMC and intends to create in-house expertise in equipment maintenance, so it will be able to take over the RTDAS after the initial AMC and warranty period. Benefits of the new systems are elaborated in Annex 3. Managers in BBMB show increasing interest in the potential for improved reservoir operations offered by the RTDSS/RTDAS, which will help the system to become fully embedded in the way BBMB manages its reservoirs and water distribution systems and manages floods. The drive from BBMB to improve the decision support for one of its key functions and the commitment of its staff and management has contributed greatly to the success of this project activity.

37. **Maharashtra Real-time Stream flow Forecasting (RTSF) and Reservoir Operation System (ROS) for flood forecasting and reservoir operation:** During MTR, Maharashtra (SW) requested funding for the development of a RTSF and ROS for the Upper Krishna and Bhima Basins at the cost of INR 310 million. It includes similar components as the RTDSS for the Bhakra-Beas Basin, and aims to reduce future flood damages and improve dry season water supply through improved reservoir management based on daily/hourly flood forecasting (see also Annex 3). The RTDAS is operational with nearly all 248 planned real-time reporting monitoring stations (automatic weather stations, rain gauges, water levels of rivers and reservoirs, and gauge-discharge stations) commissioned at Project closure. The installation of 178 spillway gate sensors for gated major and medium reservoirs in the basins was in progress. The RTSF&ROS modeling system uses flood routing and water resources system models for flood forecasting and optimization of the management of 46 reservoirs in the concerned basins. While already tested in 2013, the system was subjected to final calibration and testing during the 2014 monsoon season. Up-to-date water levels and three-day forecasts are available online (http://210.212.172.117/RTSFROS and http://210.212.172.117/Krishna/Source/Krishna.htm). Parallel operation of the new system alongside the existing systems in 2013 has demonstrated the gains to be achieved, with some operators already seeking operational advice from the system. Real-time data and water level forecasts are shared with the Maharashtra Krishna Valley Development Corporation involved in flood monitoring for the Krishna valley. The state has committed the required

funding (INR 6 million) for the spill-over activities and future software support and helpdesk facility of the RTDSS consultants, and intends to create in-house expertise in equipment maintenance, so it will be able to take over the RTSF and ROS system after the initial warranty (one year) and AMC (four years) periods. Due attention needs to be given to the feedback of stream flow forecasts and guidance for optimal reservoir operations to reservoir operators, in terms of communication means and training of field staff in order to ensure that optimal reservoir operation is indeed achieved onsite. Quantitative Precipitation Forecasting (QPF), a probabilistic approach to flood forecasting, and scenario analysis should also be given more attention during the warranty period and AMC period.

38. **Piloting of RTDAS in other states:** Inspired by results obtained in BBMB and Maharashtra, ten other states opted for the implementation of pilot RTDASs for improved reservoir operations and flood management, and real-time drought and water resources management. While networks requiring reliable communication in times of extreme weather (for flood warnings) adopted satellite (VSAT/INSAT) transmission, most of the real-time systems procured used the Global System for Mobile (GSM)/General Packet Radio System (GPRS) networks established for mobile phones, as these were simpler (lower power needs, no special government permissions) and cheaper. As per agreement between the Bank and GoI under the HP, it was mandatory that data collected in real-time are made freely available to the public through the internet. The pilot implementations agreed upon during and after MTR are:

- Andhra Pradesh (GW) installed 120 DWLRs with telemetry for enhanced drought management;
- Karnataka (SW): daily precipitation data from 1,010 standard rain gauges are daily entered and transmitted in near real-time through SMS (GSM technology) to a central server at the State Data Center; 16 AWSs and 13 river/reservoir gauging stations with radar water level sensors are equipped with telemetry. Real-time data are used for improved reservoir operations and flood forecasting and data are published in real-time on the web;
- Goa has installed eight rain gauges, two AWSs, 11 river water level recorders and 22 GW level recorders with telemetry of data in real-time;
- Gujarat (SW) has established a network of 50 AWSs with real-time reporting through GSM/GPRS; it equipped 60 river water level recorder stations with new data loggers and telemetry devices to receive the information directly through GSM/GPRS;
- Himachal Pradesh has installed 22 rain gauges, two AWSs, 16 snow gauges and 80 GW level recorders with telemetry of data;
- Madhya Pradesh (SW) has procured 28 rain gauges, three AWSs and 14 water level recorders in rivers and reservoirs for the Wainganga basin, to provide data through GSM/GPRS for assisting operational decisions for reservoirs;
- Odisha (SW): installation of 64 rain gauges, 23 AWSs and 20 water level recorders in the state, transferring information through GSM/GPRS. Installation of equipment spilled-over Project closure and Odisha has committed to fund the remaining activities;
- Odisha (GW): installation of 28 DWLR with telemetry of data through GSM/GPRS
- Puducherry has installed its entire network with telemetry, including 37 DWLRs for GW monitoring and one AWS with telemetry;
- Punjab has procured 50 DWLRs with telemetry for GW monitoring, 70 automatic rain gauges and eight water level recorders with telemetry for the monitoring of river levels;
- Tamil Nadu has installed 56 rain gauges and six AWSs with telemetry of data; and

- In parallel to HP-II, CWC has equipped 445 hydro-meteorological stations with telemetry for real-time data collection

39. **Piloting real-time water quality monitoring systems (RTWQMS):** Under this sub-component, CPCB has, for the first time, successfully installed eight real-time reporting water quality monitoring stations in the Ganga River between Haridwar and Kolkata, and two stations in Yamuna River near New Delhi's water intake at Wazirabad, for the monitoring of 10 standard water quality parameters (www.cpcb.rtwqms.com). This key achievement has set an example for India of real-time water quality monitoring for managing water quality. It has benefitted, for example, the Bank funded Ganga Project and the management of its water intake by the Delhi Water Board for the water supply of New Delhi. It also helped to manage the quality of the Ganga bathing water during the 2013 Maha Kumbh fair at Allahabad. CWC has also installed three real-time reporting water quality stations in the Ganga Basin for the real-time monitoring of six parameters. CPCB is in the process of elaborating an ambitious plan for developing a RTWQMS for the country at large, to extend real-time monitoring of water quality throughout the country for improved pollution control. Real-time water quality data will be made freely available to the public through the internet.

40. HP-II has thus successfully explored the use of RTDAS and RTDSS, enabling, amongst others, improved flood forecasting, reservoir management, flood control and drought management. Overall, the DSS sub-component has achieved its planned outcome regarding DSS-P and significantly exceeded its envisaged outputs and outcomes regarding RTDSS.

**Sub-component 2.3: Implementation of PDS**

**a) PDS implementation**

41. A total of 38 PDSs regarding SW, GW, and water quality have been successfully conducted by the state and central agencies. These PDSs were intended to encourage the various IAs to utilize the data and products developed under HP-I, supplemented with new HP-II data, to address a wide range of real-world problems of interest to them. The PDSs were thus established as a way of encouraging greater use of historical hydro-meteorological data sets and to build research capacity in applied hydrology in its broadest sense by applying longer-term data to solve a range of hydrological, hydro-geological and water quality problems throughout the participating states. The studies were 50/50 distributed between the SW and GW domains. Three planned PDSs were dropped and one PDS was converted to six pilot projects on aquifer mapping by CGWB. The PDSs focused on water quality assessment in rivers and reservoirs (four) and GW (eight), SW (seven) and GW development and management issues (10), reservoir sedimentation assessments (four), and urban hydrology and the impact of urban development on water quality (five). Overall, the PDS sub-component has provided very useful results. Some of the agencies have already disseminated salient results of the studies through agency websites and publications in national and international journals. A variety of state agencies must be involved in trying to implement successful solutions to problems identified by PDSs and raising public awareness is an important objective. Many of the problems of overexploitation or degradation of SW and GW resources will only be solved by informing the public of the problems that they themselves are contributing to and educating them to change habits.

**b) Aquifer mapping: from imagination to realization**

42. There is a paradigm shift in India from GW development to sustainable management of GW, which necessitates GW management at the local level and requires detailed knowledge of the aquifer geometry across the country. Therefore, a significant new aquifer mapping activity was agreed upon with CGWB after MTR. MoWR, RD&GR is planning to undertake a large program for aquifer mapping at a scale 1:50,000 for the entire country during the period 2013-22 ($12^{th}$ and $13^{th}$ FYPs), at an estimated cost of INR 33 billion during its first five years (www.aquiferindia.org). Inspired by the Regional Aquifer-System Analysis (RASA) program of the USGS, the vision of NAQUIM is to identify and map aquifers at the micro level, to quantify the available GW resources, to propose management plans appropriate to the scale of demand and aquifer characteristics, and introduce participatory community GW management across India. The scope of the PDS program was thus extended to financially support CGWB in undertaking comprehensive studies in six pilot regions of India, aimed at developing appropriate methodologies for large-scale aquifer mapping for improved quantification of GW resources and introduction of local management of GW. Pilot areas of 350 to 675 square kilometer ($km^2$) were located in Bihar (alluvial Ganga plains, Patna), Rajasthan (alluvium overlying hard rock, Jaisalmer and Thar Desert, Dausa), Maharashtra (basaltic traps, Nagpur), Karnataka (crystalline rocks, Tumkur) and Tamil Nadu (coastal sediments, Cuddalore), representing different geological characteristics. The pilot program was undertaken through collaboration with the National Geophysical Research Institute (NGRI, Hyderabad).

43. The main objective of the pilot program was to explore novel airborne (helicopter) TEM geophysical survey techniques for aquifer mapping, establish the utility, efficacy and suitability of these techniques for different hydro-geological environments, and establish the suitability of heliborne surveys for countrywide upscaling of aquifer mapping. The pilot program included: compilation of existing data and identification of data gaps (completed); ii) data generation to fill the data gaps including airborne geophysical surveys and exploratory drilling (completed); iii) data integration and aquifer map preparation (ongoing); iv) mathematical modeling and simulation studies (ongoing); and v) formulation of aquifer management plans (ongoing). The subsequent aquifer modeling and generation of aquifer management plans for the pilot areas was ongoing by CGWB at Project closure. Specific outcomes are presented in Annex 3. Large scale heliborne geophysical surveys allow a quantum leap in geophysical surveys and may greatly help to expedite the envisaged aquifer mapping in suitable geological formations of the country (its map able part is 2.3 million $km^2$). The preliminary assessment has indicated the efficacy of this technique in the alluvium aquifer and has recommended suitable techniques for different kinds of aquifers. These six pilot projects are thus a successful key output of the project. As shown in applications abroad, airborne geophysical surveys with a high observation density compared to traditional survey techniques allow the development of more accurate 3D GW models, benefitting an accurate assessment of GW availability and the detailed investigation of improved GW management options, such as artificial recharge. The aquifer mapping team of CGWB/NGRI has been linked with USGS scientists who have shared their experience to further improve the program.

**Component 3: Horizontal Expansion**

44. Component 3 financed four sub-components in four new HP states (Himachal Pradesh, Goa, Puducherry and Punjab), namely (i) upgrading and establishment of data collection networks, including river gauging stations, GW and aquifer monitoring systems, meteorological stations and

water quality laboratories; (ii) establishment of data processing and management systems including the development of HIS as per HP-I, establishment of data communication linkages for validation and exchange of data, and procurement of the necessary hardware, software and civil works for State Data Processing Centers; (iii) PDS; and (iv) formal and on-the-job training. Monitoring networks in the four new HP states have been strengthened through:

i. Construction of state and (sub-) divisional data centers;
ii. Strengthening of SW and GW monitoring networks by establishing new river gauging sites, meteorological stations and observation wells including automatic data acquisition equipment in Goa and Himachal Pradesh (water level recorders, AWSs, and piezometers with DWLRs);
iii. Establishing water quality monitoring stations and laboratories; and
iv. Use of advanced monitoring equipment such as ADCP.

45. Three of the new states have completed their State Data Centers while, in Punjab, center construction was still ongoing at Project closure. However, Punjab's center has been fully functional and equipped in an existing department building and this delay in construction has thus not affected HIS operation and output for the state. The Government of Punjab has committed the required funding for the spill-over works of its State Data Center. In all four states, the water quality laboratories and basic HIS monitoring networks are in place and the HIS databases for data processing and storage are functioning. All new states have undertaken PDSs to generate knowledge products and extensive staff training. Exemplary performance has been showcased by Himachal Pradesh and Goa. Himachal Pradesh embarked, in 2006, on an ambitious program, commanding after reallocation 9.3 percent of the funding under HP-II, of which it had incurred at Project closure 96 percent, making it the largest 'investor' in absolute terms under the Project. Success factors in this state are i) a single agency for SW and GW; ii) continuity in staffing; iii) support from policy levels in the state government; iv) linkages with other government departments; and v) formal arrangement of data sharing with critical stakeholders (for example, BBMB) through a signed MoU. Goa added real-time reporting stations to its monitoring network. Puducherry also performed well and has completed its initial HIS program.

**Financial Targets and Achievements**

46. ***Expenditures:*** While the project has overall achieved many of its original physical targets and several targets were increased (particularly for data processing software, RTDAS and RTDSS flood forecasting systems), expenditures (excluding ongoing but spill-over commitments) reached slightly over INR 5,500 million (87 percent) at Project closure (see Figure A1). There will be a saving of around US$13.4 million (13 percent), with total disbursements under the Project reaching US$91.58 million. Agencies which have gone well beyond their initial physical and/or financial project scope (as per the PIP) include Andhra Pradesh (GW), BBMB, CGWB, Gujarat (GW), Himachal Pradesh, Maharashtra (SW) and Tamil Nadu. CPCB, Karnataka (GW) and Madhya Pradesh (GW) have fallen significantly short of their initial PIP targets, while IMD opted out of HP-II early on in the Project. Andhra Pradesh (SW&GW), CGWB, Karnataka (GW) and Odisha (SW) all completed less than 75 percent of their 2013 reallocated budgets. Of the new HP states, Himachal Pradesh and Goa demonstrated stellar performance.

47. ***Ranking of IAs:*** Performance of the individual IAs was rated based on the scoring system shown in Table A1. Scores were assigned based on technical performance and achievements; financial

performance was not included in the scores. Instead, performance scores were weighed based on the proportionate 2013 budget allocations of the IAs, and a weighted average score was assessed accordingly. This approach ensures that, for example, a satisfactory technical performance of an IA with a large budget carries more weight than an unsatisfactory technical performance of an IA with a small budget under the Project. Eight IAs scored *Highly Satisfactory* performance and seven IAs scored *Satisfactory* or *Moderately Satisfactory* performance (Figure A1). These 15 well performing IAs represent together 63 percent of total actual expenditures under the Project. Five IAs scored *Moderately Unsatisfactory* performance, representing together only six percent of expenditures. The remaining eight agencies, representing 31 percent of total expenditures, scored *Moderately Satisfactory* performance. Overall, the 13 states scored *Satisfactory* and the eight central agencies scored *between Moderately Satisfactory and Satisfactory*. State IAs scored thus slightly better than the central IAs. The weighted average score across all IAs was *just below Satisfactory*.

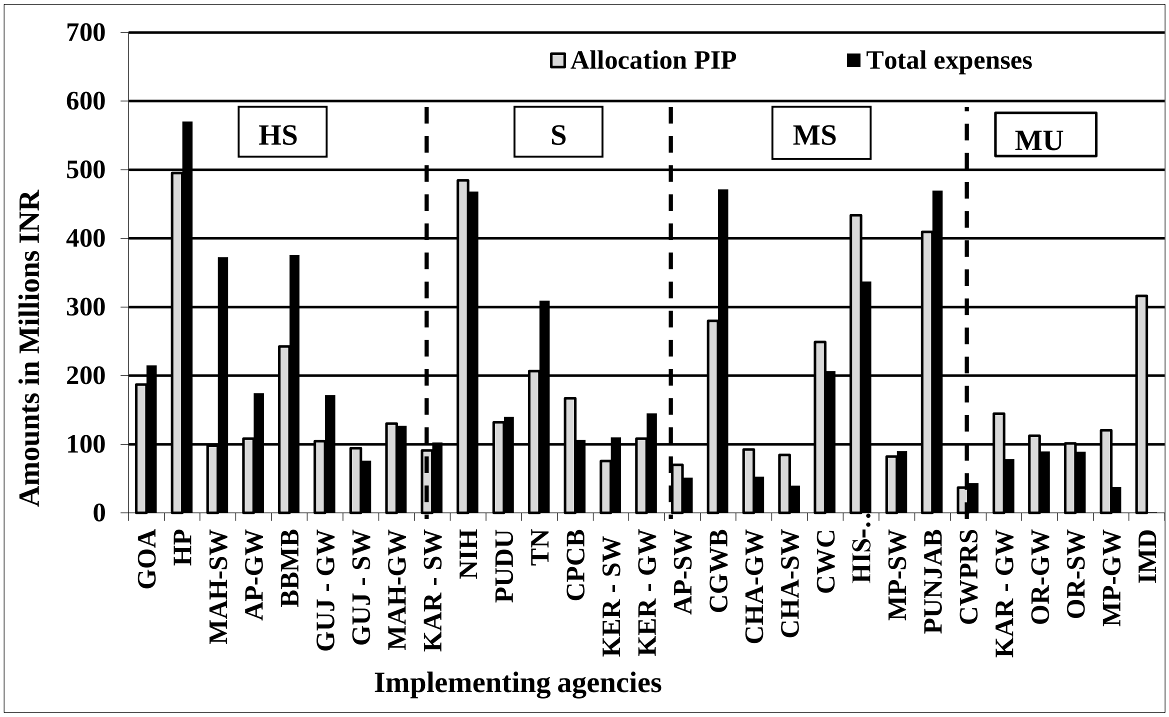


*Figure A1: Financial implementation progress (ordered from highest to lowest performance scores)*

**Table A1: Performance rating of IAs and scoring system**

| Highly Satisfactory (HS) | Satisfactory (S) to nearly S | Moderately Satisfactory (MS) | Moderately Unsatisfactory (MU) | Rating | Score | Issues |
|---|---|---|---|---|---|---|
| BBMB | CPCB | CGWB | CWPRS | HS | 5 | none |
| Andhra Pradesh-GW | NIH | CWC | Karnataka-GW | S | 4 | minor |
| Goa | Karnataka-SW | PCS | Madhya P.-GW | MS | 3 | moderate |
| Gujarat-SW | Kerala-SW | Andhra P.-SW | Odisha-SW | MU | 2 | significant |
| Gujarat-GW | Kerala-GW | Chhattisgarh-SW | Odisha-GW | U | 1 | major |
| Himachal P. | Puducherry | Chhattisgarh-GW | | HU | 0 | severe |
| Maharashtra-SW | Tamil Nadu | Madhya Pradesh-SW | | | | |
| Maharashtra-GW | | Punjab | | | | |
| **63% of total expenditures** | | **31% of expenditures** | **6% of expenditures** | | | |

48. **Committed management is key to success:** It is noteworthy that states with a combined SW and GW department appear to have performed better than states with separate departments. Important factors determining agency performance include *inter alia* cooperation and support from senior management and frequency of staff turnover. There is strong correlation between agency performance and the importance assigned to HIS by the higher echelons in the agencies. In less performing states, there is often lack of staff motivation, inadequate staffing, lack of understanding and commitment to HIS by decision makers, and thus typically lack of priority assigned to the Project from management levels. Himachal Pradesh had set a good example of maintaining leadership with the same official despite his promotion and transfer. Similarly, leadership in Kerala has demonstrated how DSS-P can be made useful in water resources planning. Instead, Punjab, Madhya Pradesh, Odisha and Karnataka-GW suffered due to varied oversight of senior management. Himachal Pradesh, Maharashtra, Goa and Puducherry witnessed minimal turnover of key staff, while project implementation in Odisha and Karnataka-GW suffered from large staff turnover and inadequate staffing.

49. ***Spill-over funding requirements:*** There is a significant spill-over of financial commitments beyond Project closure. This is due to the late award of some major software development, supply and civil works contracts. For key software development, it is also necessary that adequate arrangements are made for training, dissemination and deployment of the software, so the target users become familiar with the software. There are thus three categories of cost to be borne by the IAs after Project closure: (i) cost of completion of spill-over contracts initially intended to be fully funded under the Project, in case such contracts would have been completed prior to Project closure and the Punjab State Data Center; (ii) cost of ongoing AMC contracts for advanced software and equipment systems; and (iii) ongoing recurring cost for O&M of the HIS (staff, maintenance, and so on). The estimated budgets for category (i) are indicated in Table A2, amounting to a total of about US$5.5 million. All concerned agencies are positively committed to make the required funding available.

50. Cost estimates of AMC contracts and annual recurring cost were not readily available. However, about two-third of IAs have policies, budgets and training plans in place for sustainability of HIS, while others have stated that they will rely on regular annual budget provisions.

*Table A2: Spill-over contracts and financial commitments for AMC of various agencies*

| Sr. # | Implementing Agency | Activity | Contracts ($10^6$ INR) | AMC[12] |
|---|---|---|---|---|
| 1 | BBMB | RTDSS completion and testing | 6 | 2016 to 2019 |
| 2 | Maharashtra-SW | RTDSS completion and testing | 6 | 2016 to 2019 |
| 3 | Punjab | State Data Center completion | 40 | N/A |
| 4 | CWC | HDA development and roll-out | 43 | 2 years |
| 5 | CWC | e-SWIS completion and roll-out | 6 | 2 years |
| 6 | CGWB | e-GEMS, licenses, servers, roll-out | 160 | 7 years |
| 7 | CGWB | Aquifer mapping | 9 | N/A |
| 8 | CPCB | e-WQIS | 14 | 2015 to 2018 (INR 20 million) |
| 9 | NIH | DSS-P continuation | N/A | August 2014 onwards |
| 10 | Madhya Pradesh-SW | RTDAS | 5 | 2016 to 2019 |
| 11 | Odisha-SW | RTDAS | 43 | 2016 to 2019 |
| | Total | | 332 | |

[12] Procured equipment normally included a 24 months warranty, followed by 3 years AMC

## *Table A.3 (part 1): Agency-wise Outputs under HP-II*

| | Agency: | AP-GW | AP-SW | CH-GW | CH-SW | Goa | GU-GW | GU-SW | HP | KA-GW | KA-SW | KE-GW | KE-SW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Output/Outcome indicators** | | | | | | | | | | | | | |
| **1** | ***PDO: HIS mainstreamed by IAs and used by HDUG members to meet their planning and design needs*** | | | | | | | | | | | | |
| **1.1** | Is HIS website developed? (Y/N) | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| **1.2** | # of HDUG meetings/year | 5 | 1 S/15 D | 1 | | 0 | 1 | 1 (C+R) | 1 | | 4 | 10 | 1 |
| **1.3** | Number of Gov and Non-Government HDUG members | 51 | 52+? | 27 | | 26 | | 98 | | | 14 | 200 | 495 |
| **1.4** | Hydrology Information Needs (HIN) document available (Y/N) | Y | N | N | | N | N | Y | N | N | N | No | NA |
| **1.5** | Authorized users can access HIS through internet (Y/N) | N | N | N | | N | N | Y | Y | N | Y | No | No |
| **1.6** | Number of requests for HIS data (#/year) | | 15 | 10 | | 4 | 50 | 90 | 5 | 15 | 10 | 15 | 35 |
| **1.7** | Volume of data provided to users over the last 24 months (station years) | | 22,000 | 525 | | 4 | 800 | 74,000 | 3 Mb | 784 | 781 | | 22,813 |
| **1.8** | Average response time to data requests (# of days) | 6 | 8 | 5 | | 3 | 7 | 5 | 7 | 15 | 15 | 3 | 2 |
| **1.9** | Has user-satisfaction been surveyed? | No | Y | Y | | Y | Y | No | No | N | N | No | No |
| **1.10** | Are validated data systematically shared with other agencies | Y | Y | Y | | No | Y | Y | Y | Y | Y | Y | Yes |
| **1.11** | # of HIS public awareness activities | | 107 | 98 | 1 | | 27 | 38 | 7 | Many | 2 | Many | 17 |
| **2** | ***IRI-1: Agencies have the necessary capacity to use and promote the broad use of HIS among private & public sector users; IRI-3: HIS established in the four new States*** | | | | | | | | | | | | |
| **2.1** | HP Offices & Data Centers completed and functional (#) | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| **2.2** | SW G&D and reservoir sites fully equipped and operational: real-time (#) | | | | | 11 | | 60 | 35 | | 13 | | 6 |
| | SW G&D and reservoir sites fully equipped and operational: non-RT (#) | | 117 | | 43 | 0 | | 47 | | | 27 | | 57 |
| **2.3** | Meteorological sites fully equipped and operational: real-time (#) | AWS | | | | 2 | | 50 | 70 | | 1,026 | | 7 |
| | Meteorological sites fully equipped and operational: non-real-time (#) | | 320 | | 37 | 8 | | 129 | 55 | | | 8 | 138 |
| **2.4** | GW wells fully equipped and operational: real-time (#) | 121 | | | | 22 | | | 75 | 10 | | | |
| | GW wells fully equipped and operational: non-RT (#) | 1,017 | | 820 | | 78 | 1,002 | | 5 | 500 | | 871 | |
| **2.5** | WQ laboratories (types II & II+) fully equipped and operational (#) | 6 | 2 | 1 | 1 | 1 | 2 | 3 | 3 | 6 | 1 | 3 | 1 |
| | WQ (level I) and sediment sampling sites fully equipped and operational (#) | | 15 | | 9 | 0 | | 21 | 12 | | 12 | | 10 |
| **2.6** | How many WQ laboratories (II & II+) participate in an AQC program? | N | N | N | N | N | N | N | N | N | N | N | N |
| **2.7** | Systems for data processing & storage implemented/functional | Y | 11 | Y | | 1 | | Part. | 1 | 1 | 48 | 16 | Y |
| **2.8** | Annual O&M budget provided for HIS ('000 INR) | As required | | 1,500 | | Suff. | 1,500 | 4,258 | | | 5,000 | Y | 15,000 |
| **2.9** | Is inter-agency data validation implemented (% of data thus validated) | Y | Y | Y | | Y | Y | Y | Y | | 100% | Y | 80% |
| **2.10** | HIS staff (professionals) in place and trained (#) | 10 | | 13 | | 24 | 13 | | 11 | | 214 | 30? | 33 |
| | HIS staff (specialists) in place and trained (#) | 31 | | | | 4 | | | | | 37 | 6 | 1 |
| | HIS field staff in place and trained (#) | 28 | 31 | 46 | | 50 | 46 | | 15 | | 1,733 | 28 | 260 |
| | Percentage of HIS staff more than 2 years involved with HIS (%) | | | 50 | | 70 | 50 | | 22 | | 100 | | 70 |
| **2.11** | Training accomplished (persons) | | 448 | 91 | | 220 | 91 | 1,308 | 650 | 299 | 586 | | 33 |
| | Training accomplished (number of courses) | | 51 | 141 | | 37 | 141 | 167 | 15 | 44 | 59 | | 34 |
| | Number of in-house trainers available | | 5 | 6 | | 2 | 6 | 5 | 0 | ? | 2 | 6 | 4 |
| **2.12** | Was annual training plan and training budget approved for 2013? (Y/N) | No | Y | Y | | Y | Y | Y | Y | N | Y | Y | Y |
| **3** | ***IRI-2: IAs/users adopt HDAs & DSS for WR Planning and WR Management, and PDSs have contributed to knowledge advances in India's water sector*** | | | | | | | | | | | | |
| **3.1** | Are HDAs (SW/GW/WQ) implemented and functional within IA? | N | N | N | N | N | N | N | N | N | N | N | N |
| **3.2** | Number of basins covered by functional DSS systems | 1 | | 1 | | 0 | 1 | | 0 | 2 | | 1 + 8 | |
| **3.3** | RTDAS with or w/out flow forecasting systems implemented? | Y | N | N | N | Y | N | Y | Y | | Y | | N |
| **3.4** | Number of PDS studies completed | 1 | | 2 | 2 | 1 | 1 | 4 | 2 | 1 | 1 | | 1 |
| **4** | ***Sustainability indicators*** | | | | | | | | | | | | |
| **4.1** | Has data use been systematically monitored and documented? (Y/N) | Y | Y | Y | Y | Y | Part. | Part. | Y | Y | Y | Y | Y |
| **4.2** | Are post-project staffing & operation plans and budgets prepared? (Y/N) | N | N | Regular staff | | Y | N | N | Y | N | N | Y | Y |
| **4.3** | Is budget-line for post-project incremental staff approved? (Y/N) | N | N | Not required | | Y | Y | Y | Y | N | N | N | N |
| **4.4** | Is budget-line for post-project O&M approved? (Y/N) | N | N | Not required | | Y | Y | Y | Y | N | N | N | N |
| **4.50** | Is Training Program for post-Project period available? (Y/N) | No | No | Y | Y | N | N | Y | Y | N | Y | N | N |

## Table A.3 (part 2): Agency-wise Outputs under HP-II

| | Agency: | MP-GW | MP-SW | MA-GW | MA-SW | OR-GW | OR-SW | PUD | PUN | TN | CWC | CGWB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Output/Outcome indicators** | | | | | | | | | | | |
| **1** | ***PDO: HIS mainstreamed by IAs and used by HDUG members to meet their planning and design needs*** | | | | | | | | | | | |
| **1.1** | Is HIS website developed? (Y/N) | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| **1.2** | # of HDUG meetings/year | 1 | 0 | 40 | 1 | 4 | 4 | 1 | 1 | 6 | | |
| **1.3** | Number of Gov and Non-Government HDUG members | 252 | 19 | 577 | 2,046 | 230 | 230 | | 30 | 28 | | |
| **1.4** | Hydrology Information Needs (HIN) document available (Y/N) | | Y | Y | N | N | N | N | Y | Y | | |
| **1.5** | Authorized users can access HIS through internet (Y/N) | | No | Y | Y | N | N | Y | Y | Y | | |
| **1.6** | Number of requests for HIS data (#/year) | | 25 | 49 | 888 | 10 | 10 | | 43 | 300 | | |
| **1.7** | Volume of data provided to users over the last 24 months (station years) | | 1,600 | 165 | 78,440 | | 194 | 20 | 600 | 2,700 | | |
| **1.8** | Average response time to data requests (# of days) | | 3 | 12 | 7 | 20 | 15 | | 3 | | | |
| **1.9** | Has user-satisfaction been surveyed? | | Y | Y | Y | N | N | N | Y | N | | |
| **1.10** | Are validated data systematically shared with other agencies | | Y | Y | Y | Y | Y | N | Y | | | |
| **1.11** | # of HIS public awareness activities | No | Many | 331 | 38 | >100 | 11 | 1 | Some | | | |
| **2** | ***IRI-1: Agencies have the necessary capacity to use and promote the broad use of HIS among private & public sector users; IRI-3: HIS established in the four new States*** | | | | | | | | | | | |
| **2.1** | HP Offices & Data Centers completed and functional (#) | Y | Y | Y | Y | Y | Y | Y | 1 | Y | Y | Y |
| **2.2** | SW G&D and reservoir sites fully equipped and operational: real-time (#) | | 14 | | 83 | | 20 | | 8 | | | |
| | SW G&D and reservoir sites fully equipped and operational: non-RT (#) | | 28 | | 218 | | 56 | 4 | 28 | 121 | 1,248 | |
| **2.3** | Meteorological sites fully equipped and operational: real-time (#) | | 31 | | 193 | | 87 | 1 | 17 | 62 | | |
| | Meteorological sites fully equipped and operational: non-real-time (#) | | 62 | | 505 | | 165 | 2 | 11 | 758 | 1,170 | |
| **2.4** | GW wells fully equipped and operational: real-time (#) | | | | | 28 | | 33 | 50 | | | |
| | GW wells fully equipped and operational: non-RT (#) | 690 | | 5,050 | | 1,035 | | | 750 | 4,750 | | 15,653 |
| **2.5** | WQ laboratories (types II & II+) fully equipped and operational (#) | 7 | GW | 5 | 6 | 3 | 1 | 1 | 1 | 4 | 10 | 14 |
| | WQ (level I) and sediment sampling sites fully equipped and operational (#) | | 6 | | 21 | | 10 | | 3 | 15 | 73 | |
| **2.6** | How many WQ laboratories (II & II+) participate in an AQC program? | N | N | N | N | N | N | N | N | N | | N |
| **2.7** | Systems for data processing & storage implemented/functional | Y | 6 | Y | Y | Y | Y | Y | Y | Y | | Y |
| **2.8** | Annual O&M budget provided for HIS ('000 INR) | 180 | N | Nil | 19,233 | 600 | | | Y | Y | | Y |
| **2.9** | Is inter-agency data validation implemented (% of data thus validated) | N | Y | 80% | Y | 60% | 30% | N | N | Y | | Y |
| **2.10** | HIS staff (professionals) in place and trained (#) | | | | 2 | | 1 | 10 | 0 | Y | | |
| | HIS staff (specialists) in place and trained (#) | 10 | | | 18 | | 1 | 2 | 0 | Y | | 21 |
| | HIS field staff in place and trained (#) | 50 | 149 | | 335 | 10 | 50 | 5 | 95 | Y | | |
| | Percentage of HIS staff more than 2 years involved with HIS (%) | | | 60 | 75 | | 100 | | 80 | | | 100 |
| **2.11** | Training accomplished (persons) | | 331 | 236 | 46 | 34 | 124 | 115 | 20 | 1,000 | | 400 |
| | Training accomplished (number of courses) | | 16 | 13 | 6 | 14 | 92 | | 42 | 25 | | 22 |
| | Number of in-house trainers available | N | 2 | 8 | 23 | 3 | 1 | 2 | 3 | | | 15 |
| **2.12** | Was annual training plan and training budget approved for 2013? (Y/N) | N | N | Y | Y | Y | Y | N | ? | | | Y |
| **3** | ***IRI-2: IAs/users adopt HDAs & DSS for WR Planning and WR Management, and PDSs have contributed to knowledge advances in India's water sector*** | | | | | | | | | | | |
| **3.1** | Are HDAs (SW/GW/WQ) implemented and functional within IA? | N | N | N | N | N | N | N | N | N | | N |
| **3.2** | Number of basins covered by functional DSS systems | 0 | 1 | 1 | | 2 | | 0 | 0 | 3 | | |
| **3.3** | RTDAS with or w/out flow forecasting systems implemented? | N | Y | N | Y | Y | Y | Y | N | Y | | |
| **3.4** | Number of PDS studies completed | 3 | 0 | 3 | 2 | 2 | 2 | 1 | 0 | | | 2 |
| **4** | ***Sustainability indicators*** | | | | | | | | | | | |
| **4.1** | Has data use been systematically monitored and documented? (Y/N) | N | N | Y | Y | N | N | Y | Y | Y | | Y |
| **4.2** | Are post-project staffing & operation plans and budgets prepared? (Y/N) | N | N | N/A | Y | N | N | Y | TBD | N | | Y |
| **4.3** | Is budget-line for post-project incremental staff approved? (Y/N) | N | N | N/A | Y | N | N | N | TBD | N | | N/A |
| **4.4** | Is budget-line for post-project O&M approved? (Y/N) | N | N | Y | Y | N | N | N | TBD | N | | N/A |
| **4.50** | Is Training Program for post-Project period available? (Y/N) | N | N | N | Y | N | N | Y | TBD | N | | Y |

## Annex 3. Analysis of Project Benefits

1. As indicated in the PAD a traditional economic cost/benefit is not appropriate for this Project. As a proxy for an economic assessment a semi-quantitative assessment of benefits is provided. No specific investigations were conducted under the Project to assess benefits, even though a program to monitor data use and to identify and assess socioeconomic benefits was proposed (PAD, Annex 9). Four complementary steps were proposed for this monitoring: (i) *systematic registration* and analysis of data requests to document data dissemination; (ii) *regular documentation* of data use to identify actual use of data; (iii) *case studies* analyzing use of Project outputs to assess social, financial and economic benefits; and (iv) *consolidation of case studies* nationally to provide an overall estimate of benefits. Although requests for data and data dissemination were registered, case studies were not conducted. This Annex therefore assesses Project socioeconomic value in terms of the benefits identified by IAs.

2. Overall, there is clear evidence that extensive use is being made of the water information systems (hydro-meteorological, GW and water quality data) developed under the Project, including for project design, water resources planning, scientific investigations, and protection of water quality. The HIS will ensure significant savings on future investments and reduced maintenance costs. A nominal reduction in the investment costs for irrigation and flood control works alone would economically justify the Project investment. The benefits of the Project outputs will extend well into the future. The pressure on water resources is increasing and hence the need to manage water resources efficiently and equitably is growing. This requires adequate and accurate data, and this is only possible if HIS networks are maintained and expanded for rigorous and effective data collection and management.

3. India's 12$^{th}$ FYP calls for a paradigm shift in water resources management. It includes several objectives for improved water management, underpinned by improved water data/information, and notes that the investment in national water data and information will be a small fraction of the total FYP outlay on water resources, but the returns will be huge. Objectives most relevant to the Project include: (i) vastly improved systems for water data collection and management[13] including real-time data collection and transmission, monitoring of water use, increased transparency in data availability and enhanced data dissemination and sharing, (ii) greater priority for non-structural flood management, including improved flood forecasting and warning (using RTDAS, real-time weather forecasts, automated flood forecasting and reservoir operation modeling), and (iii) a participatory approach to GW management based on detailed aquifer mapping, GW monitoring and a National GW Management Program. In addition, the FYP calls for the preparation of integrated State Water Plans that will require improved data and application of the data in water resource assessments and modelling.

4. Benefits were generated at three levels under the Project:

i. At the *national/central level,* improved water information allows for improved water resources assessments; use of nation-wide standardized planning and design procedures; improved

[13] The 12$^{th}$ FYP proposes to: (i) install 60 Doppler weather radars supported by 40,000 real-time reporting ARGs; (ii) improve quantitative precipitation forecasting; (iii) triple the number of hydrological observation stations maintained by CWC on rivers and reservoirs to achieve various goals such as the assessment of basin-wise water availability, the study of climate change impacts on water resources, better flood forecasting, flood mitigation, reservoir inflow forecasting, water quality and sediment assessment, morphological studies, planning and design of water resources projects, etc.; (iv) create a National Water Resources Informatics Centre; and (v) monitor water utilization by source and use, including GW extraction, and canal flows in major and medium irrigation systems and water use in minor systems.

technical basis for project review and approval; support for the development and implementation of national and state water policies; improved inter-state coordination on related sector issues; non-disputable data sets to resolve inter-state water disputes; optimal water resources management; and improved uses of data amongst all water users.

ii. At the *state and basin level,* improved water information allows for improved water resources planning and design of water-related infrastructures; improved GW management; reduced vulnerability to and enhanced management of drought 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. Improved flood management will result in reductions of damage to public and private infrastructure and property (estimated in the 12$^{th}$ FYP at more than US$1 billion per year) and reduced death and displacement of people (on average 3.2 million people are affected each year by floods). Improved flood management, adequate drought relief programs and improved drinking water quality, will, amongst other Project outcomes, directly benefit the poor.

iii. At the *project and sub-basin* level, improved water information allows for improved project design and environmental impact assessment, GW impact assessment and aquifer management, water use efficiency of tanks and reservoirs, hydropower generation and irrigated water productivity and support in optimization of watershed management interventions.

**National/Central Level Benefits**

5. **National Reporting:** National data sets are used for routine reporting on the state of the water resource. GW agencies place more emphasis on routine reporting than SW agencies. The latter produce yearbooks whereas routine reports of GW agencies typically include (i) periodic reports to determine GW exploitation block by block; (ii) GW yearbooks; (iii) monthly piezometers reports; (iv) pre- and post-monsoon water quality reports; (v) district monthly water level scenario reports; and (vi) GW level forecasts for districts. The value of GW estimation reports is well understood in India – it is the primary mechanism for restricting GW access to loans for the sinking of new wells in over-exploited blocks. GW status reports are used by administration officials to monitor GW resources during droughts and to advise farmers on planting of crops. Routine reporting on GW quality information is sometimes used for monitoring the spread of water quality issues.

6. **GW Management:** In 2009 GW development in India was 61 percent of the estimated potential. Development was higher in several states and exceeded 100 percent in some states. In addition to over-abstraction, severe GW quality problems are widespread. Nearly 60 percent of all districts in India are affected by GW quantity or quality issues, or both. Collection of GW data (levels and water quality) was prioritized by GW departments and CGWB under HP-I and HP-II. These data have been used for continuous revisions to GW assessments and as a basis for GW planning at district and sub-district levels. Higher frequency and density measurement of GW levels has provided a more complete picture including (i) more accurate assessment of pre- and post-monsoon GW levels; (ii) detailed analyses of recharge processes; (iii) reducing local scale uncertainties; and (iv) timely assessment of drought-affected areas. The need for near real-time reporting of the GW status during droughts and for seasonal planning has driven improvement in GW data collections and sharing. In Andhra Pradesh and Maharashtra, GW data is reported weekly across state government, from state officials who review and classify drought to local administrators who make day-to-day plans for addressing critical shortages.

Data were used in several states (Andhra Pradesh and Maharashtra in particular) for community-based GW management that contributed to agricultural productivity increases of 20-40%.

7. The paradigm shift from GW development to sustainable management requires detailed information on the aquifer hydrogeology. The FYP proposed GW assessments be scaled-up across India through comprehensive national aquifer mapping (NAQUIM), as a prerequisite and precursor to a National GW Management Program. The long-term objective of NAQUIM is to enable local participatory management of GW as common pool resource. CGWB intends to develop a public web-based Aquifer Information and Management System (AIMS). HP-II piloted aquifer mapping through advance geophysical techniques including heli-borne TEM geophysical surveys. Preliminary assessments showed that heli-borne geophysical surveys are fast (~2,000 measurements/hour), data dense (~1,000 depth-wise information points per $km^2$), precise and cost-effective; they can be conducted in remote and inaccessible areas. The pilot surveys established the efficacy and reliability of heli-borne TEM surveys in delineating the 3-D configuration of aquifers, and indicated the approach can facilitate aquifer mapping for the entire country.

**State and Basin-Level Benefits**

8. **Development of State Water Plans and Policies.** The HIS has been used in several states to support development of plans and policies. In Maharashtra the HIS guided preparation of the State Water Plan; in Karnataka it informed new GW policy; and the BBMB developed an MoU for sharing flood forecast and water allocation data with riparian states including Himachal Pradesh, Haryana, Punjab and Rajasthan.

9. **Water Resources Development Planning and Management.** Water resources planning and management has been greatly informed by the HIS and through application of the DSS-P (Planning). The DSS-P includes tools to analyze flow time series and GIS information, to create awareness on water management issues, and to facilitate modelling for long- and short-term planning.

i. **Applications of HIS.** Irrigation development (or rehabilitation) remains a key focus for major water resources development planning in India. In Maharashtra, a total of over 700 minor and medium projects have used data from the HIS during the HP-II period. Maharashtra also recognizes the role of HIS data in the development of the real-time flood management system developed under the Project. Karnataka-SW has provided HIS data for the planning of five water supply projects for drinking water, six hydropower projects and a number of industrial projects. Gujarat-SW has identified a number of check dams and other designs of hydraulic structures where HIS data have been used. Gujarat-GW has studied the use of GW for minor irrigation in tribal areas, as an example of how the HIS data have been used for water resources planning. In Chhattisgarh, some 30 irrigation development projects, five town water supply projects, five flood protection schemes and 32 hydropower and min-hydro schemes have been provided with data from the HIS during the Project. Chhattisgarh also reports the use of GW data in the planning of irrigation schemes. Andhra Pradesh identified the use of GW data for studies on canal lining, water logging issues and the impact of GW quality on crop selection.
ii. **Applications of DSS-P** have included (i) use as a state-level hub for water resources data and information; (ii) river basin modelling for water resources planning; (iii) short-term planning; and (iv) drought advisory services through websites linked to the DSS-P database. Specific applications included:

a. **Seasonal Reservoir Operation Planning.** By considering current reservoir levels and historical inflows the DSS-P supports scenario planning for water allocation. Maharashtra has, for example, improved operation of reservoirs in the Upper Godavari Basin, thereby avoiding water scarcity during the 2013-14 dry season.
b. **Drought Management.** Droughts are often characterized by low post-monsoon storage in reservoirs and falling GW levels. DSS-P applications in various states have been used to determine sustainable water abstractions during droughts.
c. **Inter-basin Transfers.** The river basin model with DSS-P enables analysis of proposed inter-basin transfers. For example, the proposed transfer of water from the Mahanadi to Tandula reservoir was assessed in terms of amounts and timing, and the potential benefits and impacts of the proposed transfers.
d. **Multi-purpose/Multi-Reservoir Operations.** The integrated reservoir operation tool in the DSS evaluates multi-reservoir operational strategies. This has been used for the Kadana, Panam and Bhadar Reservoirs in Gujarat, for the delivery of water to the irrigation, drinking water and industrial sectors, as well as for flood control in downstream reaches of the Mahi River. This application is used to refine reservoir operations (flood control levels and operational rules); examine changes in water demands from command areas, drinking water users and industrial areas influenced by the reservoirs; and consider the impacts of changing climate and upstream conditions. Output allows reservoir managers to evaluate alternative operation strategies.
e. **Water Availability Assessments.** The Karnataka Geomatics Center developed an extended application enabling the identification of optimum locations for new projects and industrial units based on water availability. The application uses information generated by the HIS (including rainfall and station locations), digital topographical maps and rainfall-runoff relations in estimating the water availability at a given location at a given time of the year.
f. **Conjunctive SW-GW Management.** Water logging and zones of critical water deficit within two main distributaries of the Tungabhadra irrigation system in Karnataka were assessed using the DSS-P. Scenarios were examined that partition available SW from the canal network amongst the users, with different GW abstraction rates, to assess impacts on GW levels and to minimize deficits at the tail ends. This has helped move towards equitable water delivery in distributaries while maintaining sustainable GW levels.
g. **Urban Water Supplies Augmentation Projects.** Several states developed and assessed solutions for augmenting major city water supplies and have used these assessments to guide major investments. Maharashtra augmented water supplies in Pune and achieved substantial savings including as a result of replacing a proposed open channel with a pipeline saving 8.78 gigawatt hour/year (valued at USD 6.4M/per year). In Kerala, proposed check dams to augment water supplies contributed savings of over USD2.5M.

10. **Real-Time Data Acquisition, Streamflow Forecasting, DSS and Reservoir Operation Systems.** The objectives of the real-time data, forecasting, DSS and ROS are to support integrated reservoir operations decisions for optimum utilization of water and for flood warnings and implementation of evacuation measures to minimize the loss of live and damage to property. Benefits include*:* (i) reduction in water losses enabling the maximum economic outcomes to be achieved from water; (ii) reduction in flood damages, particularly at the end of the monsoon; (iii) balancing of short- and long-term objectives for reservoir management; and (iv) improved dry season water management to significantly improve water supply.

i. In the Sutlej-Beas Basin RTDAS and RTDSS enables improved organization, access and evaluation of hydro-meteorological data and forecasting of snowmelt and runoff and estimates of corresponding river flow to support a well-structured, user-friendly and complete water resources management system for the basin. Using satellite-based quantitative precipitation predictions, improved real-time data and improved hydrological knowledge, BBMB has improved the management of Bhakra and Pong reservoirs to prevent flooding and maximize storage (Table A4). The average annual flood damage for the period 2007-10 was INR 1,058 million (US$17.6 million) and an average of 23 lives were lost per year. Given the huge 2013 monsoon inflow damages and deaths well above these averages would have been expected. Project investment in the basin amounted was INR 370 million (US$6.2 million) or 15% of the 2010 flood damage bill, and much less that the potential 2013 flood damage bill. The pay-back period for the investment is thus very short and the benefit/cost ratio high, even if all other water management-related benefits are ignored.

Total reservoir inflow for 2013 was similar to 1988 when the worst floods in living memory were experienced in the Punjab, accompanied by unprecedented loss of life and property damage. Total flood damage in India and Pakistan was US$6.8 billion and the death toll was 731. 1.25 million people were displaced, and 1.5 million hectare of agricultural lands were flooded and a total of 270,000 km$^2$ were affected. If the flood damage downstream of Bhakra and Pong reservoirs was only 10% of these totals it would amount to around US$700 million. The RTDSS developed under HP-II helped to avoid flood damages of this magnitude in 2013 by enabling improved synchronization of the releases from both dams, and by informing pre-releases prior to the flood peaks based on inflow predictions.

*Table A4: Flood damages downstream of Bhakra and Pong reservoirs before HP-II and after (2013)*

| Year | Reservoir Inflow (MCM) | No. of Villages/ Town Affected | Area affected (km$^2$) | Population Affected | Lives Lost | Cattle Lost | Damage Bill (million INR) |
|---|---|---|---|---|---|---|---|
| 2007 | 11,492 | 1,033 | 1,040 | 406,000 | 7 | 3 | 586 |
| 2008 | 13,908 | 2,011 | 5,000 | 389,000 | 34 | 104 | 714 |
| 2009 | 11,181 | 545 | 1,500 | 119,000 | 15 | 74 | 539 |
| 2010 | 16,354 | 1,081 | 1,610 | 62,000 | 37 | 109 | 2,393 |
| **Mean** | | **1,165** | **5,660** | **244,000** | **23** | **73** | **1,058** |
| 2013 | 15,391 | **No Significant Loss** | | | | | |

ii. Maharashtra developed a RTSF and ROS for the Upper Krishna and Bhima Basins to reduce flood damage and improve dry season water supply through improved management of 46 major and medium reservoirs using daily/hourly flood forecasting. Previously reservoirs were operated using rigid rules requiring reservoirs to be kept full near the end of the wet season. In the case of heavy rain late in the season, reservoirs releases would cause major floods downstream. Devastating floods occurred in 2005 and 2006. In 2006, flooding downstream of Koyna Dam caused damages worth an estimated at INR 3,931 million (~US$65 million) and the loss of 68 lives (Table A5). Accurate one-day flood forecasts would have enabled major reductions in peak flows (and hence flood damage) through improved reservoir management. In Sangli, peak flow reductions would have reduced damages to a third of historic losses (INR 995 million). The cost of the RTDAS and RTSF & ROS amounted to about INR 310 million (~US$5 million) or just 8% of the 2006 flood damage bill, implying a high benefit/cost ratio. The new system was first operational in the 2013 monsoon when forecasted reservoir and river water levels and discharges were disseminated to the responsible authorities and were made available to the public through the web.

iii. Hundreds of large reservoirs across India provide dry season storage for multiple uses including hydropower, irrigation and other water supply, while also providing flood mitigation by reducing peak flows downstream. However, reservoir operations can exacerbate flooding by adhering to fixed rules uninformed by flow forecasts. High rainfall events occurring when reservoirs are close to full-supply level mean reservoirs operators must rapidly release large volumes to minimize the risk of structural damage to the dam. This can cause huge flood damages and human misery downstream. Devastating induced floods occurred in the Krishna Basin (in Maharashtra, Karnataka and Andhra Pradesh) in October 2009, leading to a death toll of over 300, an affected area of 310,000 km$^2$, over 2.5 million people displaced (mostly poor people) and direct losses of INR 320 billion. While floods were initiated by incessant rains, this was exacerbated when authorities released additional water from rain-swollen reservoirs. While forecasts, early warnings and real-time operations (coupled with disaster management services) would not have avoided all damages and deaths, these systems could have significantly mitigated impacts. The cost of these systems for the Krishna Basin would represent less than one percent of the damage of the October 2009 floods.

*Table A5: Flood damages caused by releases from Koyna Dam in 2006*

| District | Crops & Infrastructure Damage | | Land / Structural Damage | Horticulture Losses | | Total 2006 INR million |
|---|---|---|---|---|---|---|
| | Farmers | State | | Crops | Govt. Nursery | |
| Satara | 329 | 2.3 | 64 | 153 | 0.5 | 549 |
| Sangli | 744 | 3.5 | 148 | 99 | 0.4 | 995 |
| Kolhapur | 2,081 | 27 | 126 | 152 | 1.3 | 2,387 |
| **Total** | **3,154** | **33** | **338** | **404** | **2.0** | **3,931** |

11. **Real-time Water Quality Monitoring Systems (RTWQMS).** CPCB has successfully trialed a network of ten water quality monitoring stations (measuring 10 parameters) within the Ganga Basin that provide data every 15 minutes directly to a control center and website. CWC also installed three real-time water quality stations in the basin (monitoring six parameters). This new system can potentially lead to greatly improved water quality information for the Ganga Basin.

i. Documented indications of the value of these real-time data include: (i) improvements in water quality during the Maha Kumbh 2013/Magh Mela 2014 (major festival where millions bathe in the Ganga River); (ii) early detection of elevated levels of ammonia the Yamuna River to inform closure/opening of the intake to Delhi’s water supply; and (iii) informing the resolution of inter-state water issues between Delhi and Haryana.

ii. Compared to the time consuming standard (manual) data acquisition system for water quality data, the real-time system is seen as important in providing: (i) a continuous record of water quality data to detect diurnal variations; (ii) instantaneous information allowing immediate mitigation actions, publically visible on the web; and (iii) information to help understand the water quality processes in the river system.

12. **Operation of Water Resources Schemes.** Several states have used the HIS to guide the operation of water resources schemes including:

i. Andhra Pradesh: conjunctive GW studies, municipal water supply, drought monitoring and GW assessments
ii. Gujarat: solid waste management, storm water management, reservoir operations, siltation studies, evaporation studies and water quality studies
iii. Kerala: well-drilling for farmers, mini water supply schemes and drought mitigation work
iv. Maharashtra: reservoir operation for flood management, Hydropower generation and irrigation management.

13. **Water Quality and Environmental Assessments.** Water quality data and data for environmental assessments are needed for all water resources development projects as part of mandatory regulatory processes and scientific investigations. Several states have used the HIS for this purpose including:

i. Andhra Pradesh: various specific water quality investigations, routine reporting roles, water quality assessments and studies and specific monitoring requirements
ii. Gujarat: water quality investigations and assessments, and planning studies
iii. Gujarat: monitoring GW salinity, and design of projects to improve GW quality through artificial recharge
iv. Karnataka: water quality assessments for projects, base and trend analysis and evaluation of GW quality
v. Kerala: water quality studies of blocks and Environment Impact Assessment reports
vi. Madhya Pradesh: water quality monitoring, investigations and assessments

**Project and Sub-Basin Benefits**

14. **Benefits to World Bank-funded Water Projects.** Numerous World Bank-funded projects benefits significantly from use of the HIS and/or through replicating technologies rolled out during HP-II. Specific examples include:

i. *Andhra Pradesh Community Based Tank Management Project:* GW monitoring following tank rehabilitation and increased stakeholder awareness of local water resources;
ii. *Karnataka and Himachal Pradesh Watershed Projects:* State Government use of water monitoring systems to assess the efficacy of watershed interventions;
iii. *Rajasthan Water Sector Restructuring Project:* technical specifications for RTDAS adopted from HP-II;
iv. *National Ganga River Basin Program:* piloting of real-time water quality monitoring;
v. *Madhya Pradesh Water Restructuring Project:* various interventions supported by HIS;
vi. *Tamil Nadu Irrigated Agriculture Modernization and Water-Bodies Restoration and Management:* use of HIS and DSS-P to assess water availability and support basin planning;
vii. *Assam Agricultural Competitiveness Project:* implementation of real-time GW monitoring system using technology and bid documents from HP-II;
viii. *Dam Rehabilitation and Improvement Project:* replicating RT-DAS concepts from HP-II for implementation in Kerala, Madhya Pradesh, Odisha and Tamil Nadu;
ix. *West Bengal Minor Irrigation Project:* specifications and bid documents from HP-II are being used to develop monitoring systems for small streams and GW; aquifer mapping is progressing using experience gained under HP-II;
x. *Uttar Pradesh Water Restructuring Project Phase II:* specifications and bid documents from HP-II are being used for systems for GW and canal monitoring and for flood forecasting. Aquifer mapping is progressing based on experience gained under HP-II.

## Annex 4: Bank Lending and Implementation Support/Supervision Processes

### Task Team members

| Names | Title |
|---|---|
| **Lending** | |
| E. V. Jagannathan | Task Team Leader |
| Ohn Myint | Co-Task Team Leader |
| Richard W. Paulson | Water Resources Network Specialist |
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| Nagaraja Rao Harshadeep | Environment Specialist |
| Papia Bhattacharya | Financial Management Specialist |
| Manoj Agarwal | Financial Management Specialist |
| Deepal Fernando | Procurement Specialist |
| Michael Fitzpatrick | Irrigation Engineer/ FAO Team Leader |
| Elen Lemaitre | Agriculture Economist (Consultant) |
| S.Thiruvengadachari | Remote Sensing / GIS Specialist (Consultant) |
| Aris Georgakakos | Water Resources Management Specialist (Consultant) |
| Barney Popkin | GW Hydrologist (Consultant) |
| S.M. Seth | Hydrology Institutions Specialist (Consultant) |
| Jagdish Anand | Institutional Specialist (Consultant) |
| Prabir Joardar | Task Team Leader |
| Xiaokai Li | Co-Task Team Leader |
| Priti Jain | Procurement Specialist |
| S. Krishnan | Procurement Specialist |
| K.A.S. Mani | Ground Water (Consultant) |
| Anju Gaur | Hydrological Analysis/GIS |
| Asha Bhagat | Financial Management Specialist |
| S. Singh | Financial Management Specialist |
| Ai Chin Wee | Monitoring and Evaluation (Consultant) |
| H. Shi | DSS Consultant |
| Nihal Fernando | Senior Water Resources Management Specialist |
| Debabrata Chakraborti | Procurement Specialist |
| Deepak Ahluwalia | Senior Economist |
| Radhey Shyam Pathak | Senior Irrigation Specialist |
| Jacqueline Julian | Program Assistant |
| Deborah Lee Ricks | Program Assistant |
| Leena Malhotra | Team Assistant |
| John Prakash Badda | Team Assistant |
| Joop Stoutjesdijk | Lead Irrigation Engineer |
| John Briscoe | Water Advisor |
| Renjit Cheroor Sukumaran | Consultant |
| Walter A. Garvey | Consultant |
| Dhirendra Kumar | Consultant |
| Geoffrey Spencer | Senior Irrigation Engineer |
| Prem Prakash Dua | Consultant |
| Larry D. Simpson | Consultant |
| Geoffrey Spencer | Senior Irrigation Specialist |
| Harini Wijesundara | Team Assistant |
| Prachi Seth | Team Assistant |

| Names | Title |
|---|---|
| **Supervision** | |
| Winston Yu | Task Team Leader |
| Papia Bhatachaarji | Senior Financial Management Specialist |
| Debabrata Chakraborti | Senior Procurement Specialist |
| Anju Gaur | Task Team Leader |
| Nagaraja Rao Harshadeep | Senior Environmental Specialist |
| Priti Jain | Senior Procurement Specialist |
| Pratibha Mistry | Water Resources Specialist |
| Sreeshankar Nair | FAO Consultant |
| Fionna Prins | FAO Consultant |
| Prabir Joardar | Task Team Leader |
| Dhirendra Kumar | Senior Procurement Specialist |
| Natalie Giannelli | Water Resources Specialist |
| Tanuj Mathur | Senior Financial Management Specialist |
| Arun Kumar Kolsur | Senior Procurement Specialist |
| Arvind Kumar Mantha | Financial Management Specialist |
| Xiaokai Li | Task Team Leader |
| Chabungbam Rajagopal Singh | Consultant |
| Anu Priya | Consultant |
| Johan G. Grijsen | Consultant |
| Asha Bhagat | Consultant |
| Santhanam Krishnan | Consultant |
| Biva Chapagain | Consultant |
| Severin L. Kodderitzsch | Country Sector Coordinator |
| Animesh Shrivastava | Country Sector Coordinator |
| Leena Malhotra | Program Assistant |
| Jai Mansukhani | Program Assistant |
| Payal Malik Madan | Program Assistant (Procurement) |
| Haifeng Shi | Consultant |
| Srinivasan Raj Rajagopal | Consultant |
| William Young | Lead Water Resources Management Specialist |

## Staff Time and Cost

| Stage of Project Cycle | Staff Time and Cost (Bank Budget Only) | |
|---|---|---|
| | No. of staff weeks | US$ Thousands (including travel and consultant costs) |
| **Lending** | | |
| **FY04** | 30.79 | 212.65 |
| **Total:** | **30.79** | **212.65** |
| **Supervision/ICR** | | |
| **FY05** | 5.99 | 6.20 |
| **FY06** | 15.45 | 75.73 |
| **FY07** | 15.93 | 86.55 |
| **FY08** | 36.84 | 185.57 |
| **FY09** | 31.34 | 132.90 |
| **FY10** | 38.34 | 201.16 |
| **FY11** | 36.66 | 114.23 |
| **FY12** | 27.89 | 82.09 |
| **FY13** | 17.30 | 66.48 |
| **FY14** | 19.98 | 103.74 |
| **Total:** | **245.72** | **1,054.65** |

## Annex 5. Beneficiary Survey Results (if any)

Not applicable

## Annex 6. Summary and Recommendations of Stakeholders Workshops

1. Two stakeholder workshops were held in New Delhi in January and June 2014 in which all HP-II agencies and some non-HP agencies participated, as well as (from time to time) the Secretary and Additional Secretary of MoWR, RD&GR, Chairman CWC, Chairman CGWB and Country Director of the World Bank. All HP agencies presented major achievements during HP, as discussed in Annexes 2 and 3. These presentations were followed by sessions where several HP and non-HP agencies expressed their interests, needs and ideas for follow-up project interventions. The most important recommendation from stakeholders was that the HIS systems and applications developed under HP-I and HP-II needed to be scaled-up to the entire country. MoWR, RD&GR has confirmed the need for introducing the HIS as implemented under the HP to all non-HP II states, while providing further institutional strengthening and support for the development of the HIS to the present HP states and, where possible, also in newly participating states. The revised National Water Policy (2012) and 12th FYP emphasizes as well the need for a national level information system for water resources planning and management by: (i) creating a modern water information system with free exchange of data; and (ii) upgrading India's technological ability to collect, process and disseminate hydrological and environmental data. Meanwhile, in September 2014, the Bank received a request from DEA for funding of the third phase of the HP at an estimated outlay of about US$500 million.

2. While great steps have been taken under the HP II, there is still a significant way to go to make sure there is sufficient good quality data for the management of India's water resources. The value of good data on water resources for optimizing water resources management within the country is so great (Annex 3) that the importance of further HIS type interventions is hard to over-emphasize. Initially focal areas of project interventions for a third phase of HP were defined as *inter alia*: i) to support institutional development and reform for improved water resources management through development of skills and responsibilities of central and state agencies; ii) to support non-HP states in the development of HIS and provide resources for the development of improved skills and expanded HIS networks in HP states; iii) to introduce and develop the use of new technologies in monitoring and data management; iv) to improve the understanding of hydrology through river basin studies and river basin management planning; v) to improve flood warning, flood and drought management, conjunctive use and reservoir operations; and vi) to assist GW agencies in moving from development to management.

3. The proposed project would likely be centered on four main components: (i) improving Water Resources Monitoring Systems (WRMS); (ii) improving Water Information System (WRIS); (iii) Water Resources Management Applications (WRMA), and (iv) strengthening Water Resources Institutions and Capacity Building (WRICB).

## Annex 7. Summary of Borrower's ICR and/or Comments on Draft ICR

1. MoWR, RD&GR, GoI, with the help of the state and central organizations has successfully implemented HP-II during the period April 5, 2006 to May 31, 2014. Several new activities such as the development of DSS-P and DSS for flood forecasting were successfully developed for the first time in the country. Installation of RTDAS has transformed the outlook and speed of data interpretation and analysis in the organizations where HP-II has been implemented. India has joined the league of the few nations using advanced geophysical techniques such as the heliborne dual moment TEM for aquifer mapping. Implementation of these activities has laid the foundation of the management of water resources in the future.

2. The challenge faced during the implementation of HP-II was that as many as 28 Implementing Agencies (IAs) were involved. Further, a major challenge faced by the IAs was following the World Bank's procurement guidelines and documents, which were altogether new for them. MoWR, RD&GR and the Implementing Agencies, however, have been able to successfully overcome these initial delays and impediments with the result that Hydrology Project Phase-II has been completed successfully with several achievements, some of which have been briefly mentioned above. Following observations in the ICRR with respect to achievements of Project Development Objectives (PDOs) are noted:

a) Achievement of 100% with respect to Outcome Indicators (page vii, viii and ix)
b) Achievement of more than 150% with respect to Outcome Indicator (page viii).
c) Assessment of Outcomes (page 12) indicates a rating of "Substantial" in respect of Relevance (Para 3.1), Achievement (Para 3.2) and Efficiency (Para 3.3).
d) Overall Outcome Rating of the ICRR (Para 3.4), says "*in view of: (i) substantial relevance of the Project design; (ii) substantial achievement of the PDO and intended Project Outputs (with several outputs exceeding the original targets); and (iii) the Substantial Implementation Efficiency, the overall Project Outcome is rated as "Moderately Satisfactory*".

3. It is not clear that despite an achievement of more than 100% being noted by the World Bank itself, why has the overall rating of HP-II been mentioned "Moderately Satisfactory". In fact, the success of Hydrology Project Phase-II can be gauged from the fact that nearly all the States have written to MoWR, RD&GR for the next phase of Hydrology Project. The proposal for Hydrology Project Phase-III (HP-3) with a pan-India coverage has been supported by the Department of Economic Affairs (DEA) under external support from the World Bank who have also conveyed their willingness to support HP-3. The hurdles and hindrances faced in the implementation of HP-II have been noted and will be duly taken care of under HP-3.

4. In view of the above, the World Bank needs to upgrade the overall rating of Hydrology Project Phase-II and that of the Borrowers and the Implementing Agencies from "Moderately Satisfactory" to at least "Satisfactory", if not 'Highly Satisfactory', as mentioned in the draft IMPLEMENTATION COMPLETION AND RESULTS REPORT (IBRD-47490).

## Annex 8. Comments of Cofinanciers and Other Partners/Stakeholders: N/A

## Annex 9. List of Supporting Documents


1. Project Concept Note, 2003.

2. World Bank, July 2004: Project Appraisal Document Hydrology Project Phase II.

3. World Bank, March 2012: Restructuring Paper on a Proposed Project restructuring (extension) of the Hydrology Project Phase II Project Loan.

4. World Bank Project Aide Memoires (December 2006 – May 2014) and ISRs (December 2004 to May 2014).

5. Project Coordination Secretariat, 2014: Project Completion Report, Ministry of Water Resources.

6. TAMC Consultants, April 2014: Draft Final Report of the Hydrology Project Phase II, Ministry of Water Resources.

7. World Bank, IFC, MIGA, March 2013: Country Partnership Strategy for India for the period Fiscal Year 2013–2017.

8. CSIR-NGRI and Aarhus University, July 2014: Heliborne geophysical investigation in India: an innovative accomplishment in 3D aquifer mapping.

9. DHI, December 2012: Real-Time Stream flow Forecasting and Reservoir Operation System for Krishna and Bhima River Basins in Maharashtra (RTSF & ROS), draft Final Report.

10. NIH, October 2012: Development of Decision Support System (Planning) for Integrated Water Resources Development and Management, Main Report of DSS Application

11. Planning Commission, GoI, 2012: Twelfth Five Year Plan (2012–2017) for Faster, More Inclusive and Sustainable Growth, Volumes 1 – 3

12. Ministry of Water Resources, GoI, 2012: National Water Policy

13. CSIR-NGRI and Aarhus University (DK), July 2014: Heliborne geophysical investigation in India: an innovative accomplishment in 3D aquifer mapping.