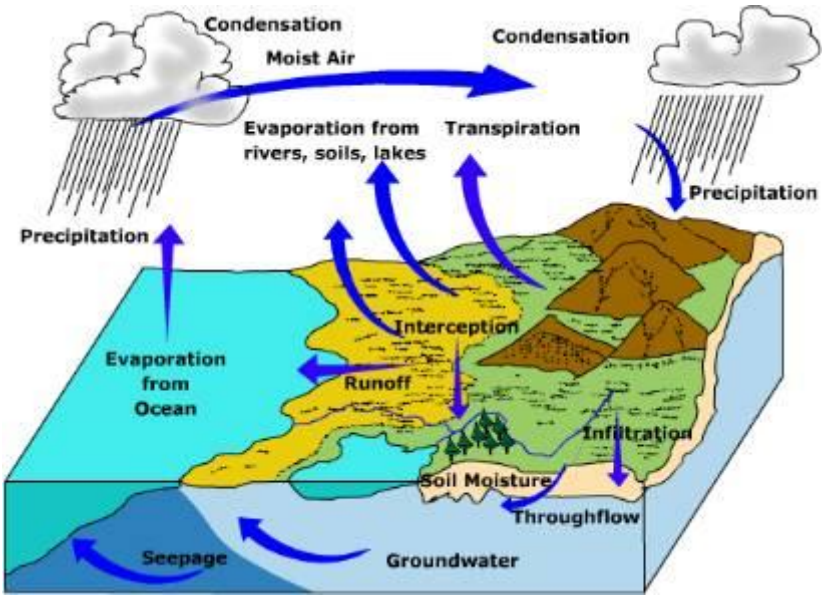
AGENDA AND AGENDA NOTES FOR THE 39th MEETING OF THE WORKING GROUP OF NIH

OCTOBER 21-22, 2013
AT 1100 HRS



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NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

AGENDA AND AGENDA NOTES FOR THE 39th MEETING OF THE WORKING GROUP OF NIH

AGENDA ITEMS

Page#

ITEM NO. 39.1 Opening remarks by the Chairman

ITEM NO. 39.2 Confirmation of the minutes of 38th meeting of the Working Group.

ITEM NO. 39.3 Action taken on the decisions/ recommendations of the previous Working Group meeting.

ITEM NO. 39.4 Presentation and discussion on the status and progress of the work programme for the year 2013-2014.

ITEM NO. 39.5 Any other item with permission of the Chair.

ITEM NO. 39.1 Opening Remarks by the Chairman

ITEM NO. 39.2 Confirmation of the minutes of 38th meeting of the Working Group

The 38th meeting of the Working Group was held during April 3-4, 2013. The minutes of the meeting were circulated to all the members and invitees vide letter **No. RMOD/38th WG/NIH/13 dated July 1, 2013**. No comments were received on the circulated minutes. A copy of the minutes of the 38th Working Group is given in **Annexure A.**

The Working Group may please confirm the minutes.

ITEM NO.39.3 Action taken on the decisions/recommendations of the previous Working Group meeting

During the 38th Working Group meeting, recommendations/ suggestions were made by the Working Group members and the actions taken shall be informed by the respective Divisions during the meeting.

ITEM NO.39.4 Presentation and discussion on the status and progress of the work programme for the year 2013-2014.

The approved Work Programme of the six Divisions of the Institute for the year 2013-14 has been given in the **Annexure B** in the following order**:**

Page#

1. Environmental Hydrology Division
2. Ground Water Hydrology Division
3. Hydrological Investigation Division
4. Surface Water Hydrology Division
5. Water Resources System Division
6. Research Management & Outreach Division (RMOD)

The numbers of studies/projects being handled by each division under different categories are given below:

Division	Studies		Total
	Internally funded	Sponsored (including HP-II)	
Environmental Hydrology	06		**06**
Ground Water Hydrology	02	04	**06**
Hydrologic Investigation	06	08	**14**
Surface Water Hydrology	10		**10**
Water Resources System	10	02	**12**
RMOD	03	01	**04**
Total			**52**

During the present meeting, Division-wise progress and status of the work programme for the year 2013-14 shall be presented in detail. The Working Group may please consider the progress and status of the Work Programme for the year 2013-2014.

ITEM NO. 39.5: Any Other Item with Permission of the Chair.

ANNEXURE – A

MINUTES OF THE 38TH MEETING OF WORKING GROUP

MINUTES OF THE
38TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING APRIL 3-4, 2013

The 38th meeting of the Working Group of NIH was held at NIH, Roorkee, during April 3-4, 2013 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 38.1: OPENING REMARKS BY THE CHAIRMAN

Er. R D Singh, Director, NIH & Chairman, WG welcomed the Working Group members and the Scientists of the Institute. The Chairman mentioned the monthly monitoring of milestones/deliverables by the Ministry of Water Resources, and suggested that the scientists should prepare the internally-funded studies in the same format as of the sponsored projects (including the provision of budget under defined heads). He advised the Divisional Heads to get such studies of 2013-14 prepared in the "sponsored project format" in their respective Divisions, which should be presented in the next meeting of the Working Group.

The Chairman then requested the Working Group members to give their general observations, suggestions and remarks on the scientific activities of the Institute. These are summarized below:

S N	Member	Suggestion(s)
1	Dr. R C Jain	▪ Advanced research to reduce uncertainty in prediction of aquifer characteristics and yield ▪ Interdisciplinary and multi disciplinary approach to solve water management issues ▪ Studies on hydraulic properties of aquifer/basin, rock formation should be planned ▪ Studies on geochemistry using knowledge of rock formation ▪ More collaboration with institutions ▪ Mechanism to reach policy makers and parliamentarians
2	Sri Sanjiv Sharma	▪ Ground water quality studies for Malwa region of Punjab where cancer cases growing with alarming rate ▪ Emphasized geological component in hydrological studies ▪ GSI can provide geologic map at scale 1:50,000 of the required study areas free of cost for research purposes
3	Dr. N B N Prasad	▪ Find out appropriate funding agencies for sponsored projects. More emphasis on sponsored studies ▪ Provide list of publications in the working group meeting agenda document ▪ Six month time for literature survey is not justifiable ▪ Select a river basin in Kerala for the PBS Program ▪ Studies on sand mining impact on ecology and water resources ▪ River inter-basin water transfer studies ▪ NIH should plan hydrological studies for at least one river basin from each State in the country

		▪ Hire services to improve presentation skill such as preparation of PPT
4	Dr. M. Perumal	▪ Plan a "Handbook of Hydrology" with chapters prepared by NIH Scientists and outside experts ▪ Softwares developed at NIH should be kept in public domain.
5	Dr. S. K. Bartarya	▪ Start student program to provide helping hand in the research activities
6	Dr. Kireet Kumar	▪ Incorporation of research finding in policy making ▪ Discussion with scientist/scientific community on data sharing issues in hydro-metrological data policy ▪ Suggested inter-Divisional linkage and mapping of studies/projects.
7	Dr. U. Saravanan Kumar	▪ Studies on isotopes, modeling and carbon dating ▪ Groundwater dating
8	Dr. R D Deshpande	**Possible areas of new / innovative research:** ▪ Dew Water harvesting ▪ Hydrothermal springs and geothermal energy as a possible source of alternate power. ▪ Submarine groundwater discharge ▪ Defluoridation experiments of using non-synthetic means such as pottery, brick, clay etc. ▪ Design and development of electromechanical sampling devices for small diameter observation wells. **Exploiting the research potential in the field of isotope hydrology, glaciology or hydrological consequences of climate change to clinch long pending scientific issues:** ▪ Eastern extent of the influence of western disturbances in Himalayan glaciers ▪ Western extent of eastern tropical jet stream in Himalayan glaciers ▪ Trans-Himalayan vapor flux ▪ Local recycling of vapor from Himalayan glaciers ▪ Post-depositional isotopic modification of snow due to evaporation and sublimation ▪ Isotopic signatures of pre-monsoon or post-monsoon characteristic weather/ monsoonal processes ▪ Standardization of parameters/ processes to identify exclusively climatic signals in hydrological indices **Applied research of societal importance and its permeation in the society:** ▪ New knowledge generated from the completed projects is translated into socio-economic advantage and the applied technology, method or approach is replicated by communities or NGOs with support (mainly consultative and marginally analytical) from NIH. This is possible by sharing the scientific knowledge, procedure, technique with organizations who can communicate with masses and teaming with them to some extent.

		Suggestions/observations concerning RMOD: ▪ Developing video conferencing facility for quick, convenient and cheaper communication with regional centers/ pilot basin studies /mass awareness programmes. ▪ Initiation of division seminars / colloquium / invited lecture series to facilitate interaction, collaboration and cooperation among scientists working in closely related disciplines. ▪ Seeking consultative guidance/ support from professional agency for developing presentation skills (oral, poster, slides) and for efficient time management. ▪ Alternative strategy of presenting new/ ongoing and completed programmes such that presentations are more effective and deliberations are much more productive in terms of achieving the targeted objectives. ▪ New studies should get maximum time to get ideas from working group members ▪ For effective organization of working group meeting, new planned studies are allowed to be presented after completion of one year ▪ Equitable distribution of time for studies of all divisions during presentations in working group meeting ▪ Mapping of a division based on its manpower, number of projects, significance of projects, external funding obtained, internal funding spent, research output in terms of international and Indian journals with their impact factors, H-index for the scientist and divisions. ▪ Placing the reports of all the completed projects on NIH website. ▪ Placing the WG minutes and reports on the website so that WG members are not required to post the hardcopy and any previous report is accessible. ▪ Current presentation screen is too small compared to the dimension of the society room. A much larger screen starting from one foot above its present position is necessary. **General comments:** ▪ Study hydrological consequences on environment ▪ Continuous study on column absorption for longer period ▪ Explore clubbing together the projects of closely similar nature, e.g. from climate change, glaciology and hydrology
9	Dr. S N Rai	▪ Concentrate on problematic areas and carry out integrated studies ▪ Emphasis must be given to develop own methodology/technology for hydrological studies e.g. modeling discharge of springs ▪ In spring flow studies, geological structure of area should be given due consideration ▪ Translate scientific results to community ▪ Continuous discussion among the groups with same area of interest to come up with innovative ideas

10	Dr. R. K. Goyal	▪ Impact assessment of climate change on water resources highlighting positive as well as negative aspects.
11	Er. N. Naha	▪ Studies on water projections for various need in the future ▪ Collaborative projects with Govt. of West Bengal.
12	Sri. N. K. Sharma	▪ Many PSU/ Corporate houses award research funding in water sector in the form of CSR. NIH may explore sponsored projects from such PSUs.
13	Er. R K Khanna	▪ Training course on environmental & social impact studies for line departments & stakeholders ▪ Environmental studies of completed projects ▪ Certificate/Diploma/PG course on "Integrated Water Resources Management (IWRM)"
14	Sri. Anshuman	▪ Study impact of climate change on water quality ▪ Coupling of research and implementation activity and assess the acceptability by people ▪ Climate change impact studies should be presented in useable form and also using WINDOW based interface for the benefit of the users ▪ Possibilities should be identified to carry out collaborative studies with TERI ▪ Prepare Policy Briefs
15	Dr. Ravi Chopra	▪ Find out mechanism to reach out to parliamentary standing committee to incoporate research finding in the policy of country ▪ Collaboration between scientific institutes, end users and implementing agencies
16	Dr. Himanshu Kulkarani	▪ Articulation of conceptual models missing in modelling studies ▪ More emphasis on field implementation of research results and good research publications ▪ Incorporate social issues into water resources management studies ▪ Fruitful collaboration between academic institutes, knowledge centers & implementing agencies (including NGOs) ▪ Need of strengthening outreach activities ▪ Proper sequencing is required during presentation of studies for understanding and convenience of committee members ▪ Time management should be exercised during presentations.
17	Sh. Kaushendra	▪ Studies on climate change adaptation strategies, highlight actionable points for users ▪ Collaboration with state agricultural university for studying impact of climate change on agricultural productivity ▪ Dissemination of knowledge at grass root level ▪ Translation of IWRM deliverables to grass root level ▪ Certificate course by NIH ▪ Improve presentations and time management during the meeting.

After taking the views of the members and their self-introduction, the Chairman asked the Member-Secretary to take up the agenda of the meeting.

ITEM No. 38.2: CONFIRMATION OF THE MINUTES OF 37TH MEETING OF THE WORKING GROUP

The 37th meeting of the Working group was held during October 29-30, 2012. The minutes of the meeting were circulated to all the members and invitees vide letter No. RMOD/37th WG/NIH/11 dated January 28th, 2013. As no comments were received on the circulated minutes, the minutes were confirmed.

ITEM No. 38.3: ACTION TAKEN ON THE DECISIONS/RECOMMENDATIONS OF THE PREVIOUS WORKING GROUP MEETING

Dr. V. C. Goyal, Scientist F & Member Secretary, gave a brief account of the actions taken on the recommendations/decisions of the 37th working group meeting.

ITEM No. 38.4: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2013-14.

The Member-Secretary made a brief presentation about organizational structure, achievement of ISO 9001:2008 to the institute and schedule & time frame for presenting the progress of studies and work programme of 2013-14. On the second day (i.e. April 4, 2013), Dr Sharad Jain chaired the meeting in absence of Er R D Singh, Director, who was on tour. Division wise minutes of each study/project presented during the meeting are given below:

ENVIRONMENTAL HYDROLOGY DIVISION
2013-14

S.No.	Title of the Study	Study Group	Date of Start and Completion
Ongoing Studies			
1.	Assessment of Water Quality in Hindon River Basin	M. K. Sharma (PI) Omkar Singh Rakesh Goyal Dayanand	DOS: 11/2011 DOC: 10/2014
2.	Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas	Rajesh Singh (PI) Dayanand	DOS: 04/2011 DOC: 03/2013 **Extended for 6 months up to Sep. 2013**
New Studies			
3.	Ground Water Quality Mapping and Surveillance for Safe Water Supply in District Hardwar and Dehradun, Uttarakhand	C. K. Jain (PI) P. K. Garg (IITR) Rama Mehta S. K. Sharma Yatveer Singh Babita Sharma	DOS: 04/13 DOC: 03/14

GROUND WATER HYDROLOGY DIVISION

YEAR 2013-14

S. No. & Reference Code	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/NIH/13-14	Estimation of specific yield and storage coefficient of aquifers	Surjeet Singh (PI) N.C. Ghosh (Co-PI) Sumant Kumar	1 year (04/13 – 03/14) **Status**: New Study	NIH
2. NIH/GWD/NIH/13-14	* State-of-the-Art Report on Modeling of Coastal Aquifers Vulnerable to Sea Water Ingress	Anupma Sharma (PI) C.P. Kumar (Co-PI) Rajan Vatsa	1 year (04/13 – 03/14) **Status**: New Study	NIH (Reffered by MoWR)
Sponsored & HP-II Projects				
3. NIH/GWD/HP-II/10-12	Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat.	N. C. Ghosh (Coordinator) Anupma Sharma (PI) C P Kumar SE(GWRDC, Gujarat) C.K. Jain Sudhir Kumar D.S. Rathore M.S. Rao Surjeet Singh Rajan Vatsa	3 years (10/09 – 12/13) **Status:** Continuing	PDS (HP-II)
4. EU-sponsored Project no. 282911	Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India"	Project Coordinator & P.I. : N. C. Ghosh Other Team Members V. C. Goyal C. K. Jain Sudhir Kumar B. Chakravorty A. K. Lohani Anupma Sharma Surjeet Singh Sumant Kumar Shashi Poonam Indwar	36 months (Oct., 2011-Sept.,2014) Status: Continuing	European Union under 7th - Framework Programme
5. NIH/GWD/NIH/11-14	Management of Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)	Sumant Kumar (PI) Rajan Vatsa N.C. Ghosh C.P. Kumar Surjeet Singh Sanjay Mittal	3 years (04/11 – 03/14) **Status:** Continuing	Saph Pani Project
6. EU-sponsored Project	Flow and Contaminant Transport Modeling of	Shashi Poonam Indwar (PI)	2 ½ years (04/12 –	Saph Pani Project

no. 282911	Riverbank Filtration	N.C. Ghosh Anupma Sharma Rajan Vatsa Sanjay Mittal **Support:** Uttarakhand Jal Sansthan (UJS	09/14) **Status:** Ongoing	
Consultancy Project				
	Drainage Area Mapping and Hydrological Studies in and around Gurha (W) Block in Kolayat Tehsil of Bikaner District, Rajasthan	N.C. Ghosh (PI) Surjeet Singh Rajan Vatsa Sumant Kumar S.P. Rai Sanjay Mittal	09 months **Status:** In progress	RSMML, Rajasthan

Division proposed to organize two Brainstorming session/Training courses on following topics:

(i) Brainstorming session, probable topic:

Managed Aquifer Recharge for sustainable groundwater development & management / Bank Filtration for sustainable drinking water supply /Drinking water source sustainability.

(ii) **Training course, probable topic:**

Coastal groundwater modelling and management / Groundwater modelling and management / Managed aquifer recharge or Artificial Groundwater Recharge / Conjunctive use of surface water and groundwater.

HYDROLOGICAL INVESTIGATIONS DIVISION
2013-14

S. No.	Title of Study/Project, Study Team,	Study Group	Date of Start and Date of Completion
1.	Assessment of Sensitivity of Open Water Evaporation to Increase in Temperature for Different Climatic Regions of India	S. D. Khobragade (PI) C. P. Kumar Manohar Arora A. R. Senthil Kumar	DOS: 04/2012 DOC: 03/2014
2.	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab	M. S. Rao (PI) C. P. Kumar Gopal Krishan	DOS: 07/2012 DOC: 06/2014
3.	Water Availability Studies for Sukhna Lake, Chandigarh	S. D. Khobragade (PI) C. P. Kumar Sudhir Kumar A. R. Senthil Kumar P. K. Garg, V. K. Agarwal	DOS: 04/2013 DOC: 03/2015
4.	National Program on Isotope Fingerprinting of Waters of India (IWIN)	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. P. Rai S. K. Verma P. K. Garg	DOS: 07/2007 DOC: 06/2013
5.	Groundwater Dynamics of Bist-Doab Area, Punjab using Isotopes	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. K. Verma P. K. Garg CGWB Officials	DOS: 10/2008 DOC: 12/2013
6.	Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka	Sudhir Kumar (PI) J. V. Tyagi S. P. Rao Anupma Sharma B. K. Purandara C. Rangaraj	DOS: 10/2008 DOC: 03/2014
7.	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	M. S. Rao (PI) C. P. Kumar S. P. Rai	DOS: 09/2012 DOC: 08/2013
8.	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI) M. S. Rao Surjeet Singh S. K. Verma C. P. Kumar Sudhir Kumar V. K. Agarwal Rajeev Gupta	DOS: 06/2012, DOC: 05/2015

		S. L. Srivastava Vishal Gupta Mohar Singh	
9.	Review of Groundwater Resources in the Indo-Gangetic Basin: A Case Study on Resilience of Groundwater in the Punjab to Withdrawal and Environmental Change	M. S. Rao (PI) C. P. Kumar Gopal Krishan	DOS: 02/2013 DOC: 05/2014
10.	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar V. K. Agarwal, Vishal Gupta, Mohar Singh	DOS: 10/2012 DOC: 09/2015
11.	Isotope Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI) C. K. Jain S. P. Rai S. D. Khobragade P. K. Garg Two Officers from CGWB	DOS: 07/2013 DOC: 06/2015
12.	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management	S. D. Khobragade (PI) C. P. Kumar R. D. Singh Sudhir Kumar S. P. Rai, C. K. Jain V. K. Agarwal	DOS: 07/2011 DOC: 06/2013
13.	Pre-dredging and Post-dredging Bathymetric Survey of Ramgarh Tal Lake, Gorakhpur, UP	S. D. Khobragade (PI), C. P. Kumar R. D. Singh V. K. Agarwal	DOS: 11/2012 DOC: 04/2013 (Pre-dredging)
14.	Assessment of Impact of Coal Mining from Mahan Coal Block on Groundwater Recharge and Sedimentation in Rihand Reservoir and to Suggest Appropriate Measures to Mitigate the Identified Impacts	Sudhir Kumar (PI) Sanjay Kumar Jain Jai Vir Tyagi Surjeet Singh S. D. Khobragade R. K. Jaiswal P. K. Garg	DOS: 04/2013 DOC: 09/2013

SURFACE WATER HYDROLOGY DIVISION

Dr. Avinash Agarwal, Scientist F presented brief details of various studies carried out under the Surface Water Hydrology Division during 2012-13 as well as other research and technical activities and also the proposed studies for the year 2013-14. The progress of studies was then presented by the respective P.I. of the study. The details are as under.

A. PROGRESS OF WORK PROGRAMME FOR THE YEAR 2012-13

1. SNOWMELT RUNOFF MODELING AND STUDY OF THE IMPACT OF CLIMATE CHANGE IN PART OF BRAHMAPUTRA RIVER BASIN

Mrs Archana Sarkar, PI of the study presented the statement, objectives, study area, approved action plan, methodology, results and deliverables of the study (completed). She informed that study area is the Subansiri River basin, the biggest northern tributary of Brahmaputra River within India which originates in Tibet, contains snow-fed tributaries and glaciers and has a huge hydropower potential. Snowmelt runoff modeling for the Subansiri basin and study of the impact of climate change on basin runoff has been carried out for the first time and the results of the present study would be very useful for water resources planning and management in the region. Dr R.D. Despande enquired about the time required for procurement and processing of MODIS data. Mrs Sarkar replied that she took about six months time for procurement and processing of seven years of MODIS data for the Subansiri basin.

2. IMPACT OF CLIMATE CHANGE ON GLACIERS AND GLACIAL LAKES: CASE STUDY ON GLOF IN TISTA BASIN

The study was presented by Dr. A K Lohani. He explained the importance and objectives of the study. He further presented the results of glacial mapping and GLOF modeling . Dr Lohani informed that the analysis is complete and he presented the results in detail. Shri Ravi Chopra asked the reasoning of high flood value at lake side and low flood at project site. Dr Lohani explained the flood routing method adopted for modeling and further explained the reasoning of attenuation of flood peak.

3. CLIMATIC SCENARIOS GENERATION FOR SATLUJ BASIN USING STATISTICAL DOWNSCALING TECHNIQUES

Dr Arora presented the progress of the study. He presented the results of the AO GCM quantitative evaluation of the downscaled output of the data for precipitation and temperature for the period 1980 to 2000 for the Satluj basin. He explained the analogy used for quantitative evaluation and presented the downscaled output for the 20^{th} Century raw data and 20^{th} Century corrected data. The raw data for A1B scenario and the corrected data for A1b corrected scenario were also presented. The extreme values in rainfall data were ranked and presented after bias correction. There were no specific comments from the members. Dr V C Goyal wanted to know whether the study is completed. The PI informed that the study is complete and final report will be submitted.

4. CLIMATIC VARIABILITY ANALYSIS AND ITS IMPACT ON HIMALAYAN WATERSHED IN UTTARAKHAND.

Dr. Avinash Agarwal presented the study and the results in the light of suggestion from previous meeting. Presented study area and methodology and results so obtained in details along with the climatic variability and the impacts on stream and spring flows. It was informed that the study will conclude by next working group meeting. Dr. SN Rai inquired for any relation developed between measured climatic variables and soil moisture. In was informed that no such work has taken up in this study, but the data is sufficient and it can be taken up in next study. Discussion held on modeling of cumulative spring, recession flow and variability of spring behavior and its broad classification.

5. MONITORING AND MODELLING OF STREAMFLOW FOR THE GANGOTRI GLACIER

Dr Arora presented the progress of the study and informed that the data collected for the ablation period of 2012 has been analyzed and the results were presented. He informed the house that the discharge was less in comparison to previous years. Shri Kireet Kumar was interested to know the discharge during the winter months. The PI replied that the winter data is being analysed. Dr S N Rai wanted to know the gist of the results from this long term study. Dr Arora explained the motive behind this long term study and the results obtained. Dr S K Jain was interested in knowing the lag time for the flow at the discharge site. It was informed that initially during the start of the season the lag time is about one day and reduces to about 4 hours as the season progresses.

6. HYDROLOGICAL STUDIES FOR UPPER NARMADA BASIN

Mr. Jagadish Prasad Patra, PI of the study presented the progress during past two year of the ongoing three year study scheduled to complete by March 2014. Objectives of the study with brief methodology and work progress in past six months are presented. The Calibration and validation of mike-11 model along with Mike-flood model setup were discussed in details during the presentation. There were no specific comments from the members.

7. STUDY OF HYDRO-METEOROLOGICAL DROUGHTS FOR BUNDELKHAND REGION IN INDIA

The PI of the project presented progress of the study and informed the house that the Bundelkhand region of the country is currently facing drinking water shortages during summer months and this problem has become more severe during drought years in the recent past i.e. 2004-2008. The major objective of the study is to quantify water scarcity during droughts and to identify possible options for augmenting water supply and minimizing crop loss due to droughts**.** The PI further reported that th**e** necessary base maps required for this study have been prepared. These include maps of DEM, drainage, soil, landuse etc. It was reported that long-term monthly rainfall data for 1901-2010 and daily rainfall and other meteorological records for 1969-2011 were collected and analyzed for rainfall departure and dryspell analysis and presented in the meeting. It was informed that a new methodology has been devised for regular drought monitoring using rainfall data. The method has been compared with Standardized Precipitation Index (SPI) and Effective Drought Index (EDI). The method provides comparable assessment of onset of drought and its progression. Further refining works on this methodology will be carried out. IT will also be evaluated for other

sites. The PI informed that the flow measurement record for Paisuni river are not available. Therefore, MIKE Basin NAM Model has been used to estimate flow series using Tons flow data for its calibration. It is hoped that this study will be useful to devise area specific plan for water management in the study area to deal with the drought situation in study area. It was informed that the interim Report on progress of this study is under preparation and it will be submitted in April 2013.

8. SEDIMENTATION STUDIES FOR PONG RESERVOIR, HIMACHAL PRADESH

Dr. A. R. Senthil kumar, PI of the project, presented the objectives, methodology and progress of the study for the period from October 2012 to March 2013 in brief. He presented the development of sediment yield model for pong dam using ANN and the simulation of sediment yield for future 25, 50, 75 and 100 years using the generated series of rainfall and flow volume. He also presented the future work to be carried out for the next six months. There were no queries from the members of the working group.

B. NEW STUDIES FOR 2013-14

1. DEVELOPMENT OF REAL TIME FLOOD FORECASTING FOR DOWNSTREAM OF HIRAKUD DAM

Dr. A K Lohani presented the background and objectives of the proposed study. Dr Lohani mentioned that the floods are among one of the most destructive acts of nature. Flood forecasting is used to provide warning to people residing in flood plains and can alleviate a lot of distress and damage. Flood forecasting is an important non-structural solution for reducing flood damages and is used to provide warning to people residing in flood plains. Dr Lohani mentioned that the soft computing based models will be developed and for the downstream of Hirakud dam.

2. STATUS REPORT ON SOIL EROSION AND SEDIMENT TRANSPORT MODELLING

Dr. J. V. Tyagi, PI of the study informed the house that the National Water Mission document of National Action Plan on Climate Change (NAPCC) has recommended for building a Universal Soil Loss model depicting erosion and sediment transport etc. Before taking up the model development, the action plan of the activity envisages preparation of a state-of-the-art report on soil erosion and sediment transport modeling and the work is entrusted to NIH. Accordingly, preparation of state-of-the-art report has been taken up. Dr. Tyagi further informed that the literature on soil erosion and sediment transport modeling would be collected from web resources, academic and R&D institutions. A thorough review of the collected literature and analysis of various methodologies available for soil erosion and sediment transport modelling would be carried out for preparation of the state-of-the-art report. Dr S.N. Rai suggested for modifying the objective to incorporate the development of the model in the present report. Dr. Tyagi informed that the development of the model will be taken up in the second phase in collaboration with other R&D institutes as have been identified in the action plan. The present state-of-the art-report has to be submitted in six months and will serve as a guiding document for development of the appropriate model.

3. APPLICATION OF DSS(P) FOR INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT

Dr. A K Lohani presented the background and objectives of the proposed study. Dr Lohani mentioned that the DSS(P) software has been developed under HP-II and the same model will be applied in a selected basin to demonstrate the capabilities of the DSS(P) model. Members of the working group appreciated the proposed study.

4. QUANTITATIVE ASSESSMENT OF UNCERTAINTIES IN RIVER DISCHARGE ESTIMATION

Dr. Sanjay Kumar proposed the study. He explained the background and objectives of the study and mentioned that the proposed study is a part of the systemic review of uncertainty clause of the ISO 9123 document as recommended by the India member body of ISO. He explained the methodology based on ISO documents GUM (Guide to the expression of uncertainty in measurement), HUG (Hydrometric uncertainty guidance) and presented the work plan for the study. The members inquired about the discharge measurement methods and the assessment of associated uncertainty. Dr. Perumal mentioned that uncertainties in the velocity measurements using current meter compared to velocity measurements using float are considerably different and should be considered for overall uncertainty estimation in discharge observations. Dr. Sanjay Kumar replied that this will be considered as per the guidelines in HUG and GUM and other related ISO standards on flow measurement.

5. SUSPENDED SEDIMENT FLUX MODELLING IN THE LARGEST SUB-BASIN OF BRAHMAPUTRA

Mrs Archana Sarkar, PI of the study presented the background, objectives, methodology and expected deliverables of the new study. Mrs Sarkar informed that the study area is the Subansiri River basin. She informed the house that Hydrological modeling studies in Brahmaputra basin" is one of the thrust areas of "12^{th} Five Year Plan" of the institute. She further informed Subansiri River promises stupendous hydropower potential (22 projects having potential of 15,191 MW already proposed/in progress) for the country, therefore, accurate assessment of sediment flux is of prime importance. Mrs Sarkar proposed back propagation feed forward ANN models to be developed to simulate the suspended sediment flux for the catchment of Subansiri River up to Choudhuaghat gauging site using various combinations of the historical data of rainfall, rainfall intensity, temperature, snow cover area, discharge and suspended sediment concentration on daily, ten-daily and monthly basis. Sediment rating curves (SRC) and multiple linear regression (MLR) models would also be developed to simulate the suspended sediment flux for the catchment of Subansiri River up to Choudhuaghat gauging site using data similar to that used for ANN models for inter-comparison of developed models. Mrs Sarkar informed that this study would conclude by providing discussion about how the different type of input data, length of input data, lagging of input data and scale of input data effect the accuracy of sediment flux estimation in a large Himalayan River basin and also guidance on the types of tasks for which different types of input data may be preferable.

WATER RESOURCES SYSTEM DIVISION

1. Ongoing study: Web GIS based snow cover information system for Himalaya

The progress of the study was presented by Mr D.S. Rathore. In the study, MODIS data MOD09A1 were downloaded for year 2007 and data for selected dates in 2007 were processed using partial MODIS snowmap algorithm. Many data/ area are cloud free and thus useful information is extracted from the data. Sub basins were delineated from SRTM250 data. Snow cover zonal statistics and depletion curves were prepared. The snow cover maps were generalized and polygonized. Polygon data (snow cover and sub basins) were published in desktop environment using GeoServer Web GIS software. OpenLayers web pages created in GeoServer were also used in HTML document. HTML document was demonstrated. Permission for dissemination of the processed Aphrodite rainfall data was not received till date and thus these data were not included in the study. Final resolution data (Landsat ETM+ for complete area and AWiFS for part of the area) and SRTM 90 m were downloaded but were not included in the application in paucity of elaborate plan. Dr Anshuman inquired if the maps are available for download. Mr Rathore replied that the data may be consumed in desktop web GIS clients e.g. ArcGIS, Quantum GIS etc. Chairman noted that the some of the slides in the presentation were lacking titles.

2. New Study: Web GIS based snow cover information system for Indus basin

The study proposal was presented by Mr D.S. Rathore. Several elaborate algorithms are available for delineation of snow cover maps. Snowmap algorithm of NSIDC has global applicability and is useful for automatic mode. Other algorithms are also available. Methods were also used for post processing. Snow masks are also available with varied information. It is proposed to use variations of the algorithm for finding suitable method for manual and region delineations. The algorithm development will be done for Indus basin. The generated maps will also be published on web using server e.g. GeoServer. Javascript with OpenLayers library will be used for generating web pages.

3. Completed study: Software for Frequency Analysis in Hydrology

Mrs. Deepa presented the study. She informed that a menu driven, user-friendly software has been developed in Visual Basic language to carry out frequency analysis with of hydrological data using different distributions. This software calculates probability plotting positions, estimate the parameters of the various statistical distributions, evaluate the fit of these distributions, estimate flood quantiles, and compare estimates. The software also computes the maximum likelihood estimates of probability distribution parameters for several statistical distributions used in flood frequency analysis.

4. New Study: Assessment of Water Footprint of the National Capital Territory (NCT) of India

Mrs. Deepa presented the study. She informed that the water footprint of a country is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of the country. The water footprint is divided into a blue, a green and a gray component. The blue component refers to the evaporation of groundwater and surface water during the production of a commodity, the green component to the evaporation of rain water for crop growth, and the gray component to the water required to dilute the water pollution that is caused by the production of the commodity to acceptable levels.

The New Delhi – the National Capital Territory (NCT) of India, a metropolitan cities with a population of 1.67 crore (Census, 2011) is the second largest populous cities in India. There are huge variations in supply, primarily due to the population expanding at a rate that was never factored in plans. To get more insight on whether the water scarcity in the NCT region is a manifestation of local consumption or by the increasing industrial demand, the water footprints of the region needs to be assessed with the following major objectives:

- To quantify the different components of water footprint i.e. Blue; Green, & Gray components of the NCT region;
- To assess the international and interstate virtual water flows from and to the NCT region to establish the virtual water balance;
- To analyze past-present-future water footprint of the NCT region for making realistic water management plan;

Sri R C Jain enquired whether this study has been sponsored by some organisation. Mrs Deepa replied that this is an internally funded project. Sri Anshuman informed that his institute is also working on water footprint. He suggested that in this type of study boundary should not be a constrained.

5. Completed study: Mathematical representation of Elevation-Area-Capacity curves for Indian reservoirs

Dr. M. K. Goel (MKG) presented the progress of the study. He informed that based on availability of data, original and revised Elevation – Area and Elevation – Capacity tables for a number of Indian reservoirs have been digitized. The reservoirs have been divided in four different types according to the shape of the gorge and characteristics of submergence area (Gorge, hill, foothill, and flood plain etc.). The methodology of the study has been programmed in MS-Excel and analysis for various reservoirs under various types has been carried out. He elaborated that for a particular type of reservoir, dimensionless (relative depth vs. relative area or relative capacity) graphs have been plotted for the live storage zone of reservoirs in normal and Log scales. The dimensionless plots for common type of reservoirs have been clubbed to find their range of variation. The capacity curves mostly converge within a close band which can be represented with unique mathematical equations. However, the variation for area curves was found to be large. He showed the dimensionless plots for some reservoir types. MKG informed that data for some more reservoirs is being incorporated in the analysis. He asked for three months extension for the completion of study which was approved.

6. New Study: *NIH_Basin* – A WINDOWS based model for water resources assessment in a river basin

MKG presented the study in detail. He informed that a basin-scale model has been developed at NIH in the past. He briefly presented the methodology for the model and its output. He informed that there are some limitations which need to be overcome. Some of these limitations include: i) specification of EAC tables or corresponding relationships for various storage structures, ii) rule-curve based operation of reservoirs so that different operation policies of the system can be simulated, iii) option of hydropower simulation in the basin, iv) routing of flows, and v) simpler representation of groundwater modeling aspects at river basin scale. He informed that efforts would be made to make refinements in these aspects. Further, it is envisaged to develop a WINDOWS interface (named as NIH_Basin – NIH_Basin-Simulation) of the model for easy application by the user groups.

Sh. R. C. Jain, CGWB, informed that GW contribution from beyond the basin boundaries (based on geological structures) is a limitation of basin scale models. In response to a query from Dr. S. N. Rai, NGRI, regarding the rainfall computation (which is an input to model), MKG informed that computations are made for estimation of rainfall volume over various land uses in different sub-basins which becomes an output for evaluation of hydrological components for those land uses. Some discussions were held by Dr. S. N. Rai and Prof. M. Perumal, IIT-Roorkee regarding the marketing, pricing, and outreach of the modeling tools developed at NIH. Dr. Anshuman, TERI made a remark that SWAT model can be linked to a groundwater model, such as MODFLOW for groundwater simulation.

7. Ongoing study: Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range

8. Ongoing study: Glaciological studies of Phuche glacier, Ladakh Range

Dr Renoj J Thayyen, Scientist "D" has been recently transferred from WHRC Jammu to NIH Roorkee. He was PI of the above two studies which have also been transferred to HQs. Dr Thayyen presented the two studies. There were no specific suggestions/ comments from any Working Group Member.

9. PDS Study: Hydrological assessment of un-gauged catchments by Dr. P. K. Bhunya, Scientist "D"

Dr. P K Bhunya apprised the committee about the completed project on Hydrological assessment of un-gauged catchments and was presented in a gist as the time was short. Next, he proposed a new project titled impact of climate and land use change on floods of various return periods. Apprised the committee about the objectives, methodology to be followed in this study coupled with phase wise works to be done as per the time program, referred works and the deliverables. The study area was also focused in the meeting out of which the major basin is Mahanadi from state of Orissa and that was considered in the HP2 project. There were no such queries or comments from the working group members.

10. New study: Impact of climate and landuse change on floods of various return periods

Dr. P K Bhunya presented the above proposed study.

11. Ongoing study: Event-based rainfall runoff modelling using soft computing techniques

12. Ongoing study: Analysis of water management scenarios in Tapi river basin using MIKE basin software

Both the studies were presented by Dr. Rama Mehta, Scientist "C". No specific suggestions/ comments were received from any Working Group Member.

13. Ongoing study: Trend and variability analysis of rainfall and temperature in Himalayan region

The study was presented by Sh. L. N. Thakural. The objective of the study is to create the database (Rainfall, Temperature) for the Himalayan region and carry out statistical analysis to detect trend and variability in these variables in the Himalayan region, India. The parametric and non-parametric approaches will be used to determine the trends in the time series data of these meteorological variables. During the presentation temporal and spatial characteristics of the temperature and rainfall hydro-meteorological were explained. The parametric and non-

parametric approach used to find out the trend in temperature and rainfall time series at the observational sites in central Himalayas was presented. Sh Ravi Chopra informed that data for Chaukhutia station can also be explored station. He also said that IMD Pune can be visited and availability of more data at other observational sites can be explored. There were no specific comments

14. New Study: Assessing climate change impact across KBK region of Odisha

The proposed new study was presented by Shri P.K. Mishra on behalf of his team. The study envisages identifying long-term trend and its attributes for the KBK region. Also, the current and future water scenario for the region will be assessed for suggesting a reliable water management plan. In the end of the presentation, Dr. N.C. Ghosh, Scientist "F", GWH Division, NIH Roorkee enquired whether groundwater component is included while assessing the water supply & demand in the region during the proposed study. The PI proposed to include only the surface water components or else assumptions will be made on the likely availability and utilization of groundwater in the region based on available data/ literature if any. Further, the PI evinces his interest to seek Dr. Ghosh's help in this regard.

WORK PROGRAMME OF WRS DIVISION FOR YEAR 2013-14

S.N.	Title	Study Team	Duration	Funding
Ongoing Internal Studies				
1.	Mathematical representation of Elevation-Area-Capacity curves for Indian reservoirs	M. K. Goel Sushil K. Singh P. K. Agarwal	1 year (4/12-3/13) **Completed study**	NIH
2.	Event-based rainfall runoff modelling using soft computing techniques	Rama Mehta Sushil K. Singh Yatveer Singh	1 year (4/12-3/13) **Completed study**	NIH
3.	Analysis of water management scenarios in Tapi river basin using MIKE basin software	Rama Mehta M.K.Goel D.S.Rathore	3 years (4/10-3/13) **Completed study**	NIH
4.	Web GIS based snow cover information system for Himalayas	D. S. Rathore D. Chalisgaonkar L. N. Thakural Tanvear Ahmed	1 year (4/12-3/13) **Completed study**	NIH
5.	Software for frequency analysis in Hydrology	D. Chalisgaonkar D. S. Rathore Sushil K. Singh M. K. Goel	1 year (4/12-3/13) **Completed study**	NIH
6.	Trend and variability analysis of rainfall and temperature in Himalayan region	L.N.Thakural Sanjay Kumar Sanjay K. Jain Sharad K. Jain Tanvear Ahmed	3 years (10/11-09/14) **Continuing study**	NIH

Sponsored Studies				
1.	Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin	Sanjay K. Jain S. P. Rai L. N. Thakural	3 years (4/09-12/13) **Continuing study**	PDS (HP-II)
2.	Assessment of effects of sedimentation on the capacity/life of Bhakra reservoir (Gobind sagar) on river Satluj and Pong reservoir on river Beas	Sanjay K. Jain J. V. Tyagi Rama Mehta	3 years (4/09-6/13) **Continuing study**	PDS (HP-II)
3.	Hydrological assessment of Ungauged Catchments (Small catchment)	P.K. Bhunya Rakesh Kumar Sanjay Kumar D.S. Rathore P.C. Nayak	4 years (5/09-3/13) **Completed study**	PDS (HP-II)
4.	Title: Preparation of Ganga River Basin Environment Management Plan (GRBEMP)	Dr Sharad K Jain, PI Dr N C Ghosh, Dr Sanjay K Jain, Dr M K Goel,	Till Dec. 2013	Funding by MOEF thru IIT Kanpur, Rs 12.0 Lakhs
New Internal Studies				
1.	NIH_Basin A WINDOWS based model for water resources assessment in a river basin	M.K. Goel S.K. Jain D. Chalisgaonkar P.K. Mishra	2 years (4/13-3/15) **New study**	NIH
2.	Impact of climate and landuse change on floods of various return periods	P.K. Bhunya Sanjay Kumar D.S. Rathore	2 years (4/13-3/15) **New study**	NIH
3.	Web GIS based snow cover information system for the Himalaya	D.S. Rathore D. Chalisgaonkar L.N. Thakural T. Ahmed	2 years (4/13-3/15) **New study**	NIH
4.	Assessment of Water Footprint of the National Capital Territory (NCT) of India	D. Chalisgaonkar Sharad K. Jain P.K. Mishra	2 years (4/13-3/15) **New study**	NIH
5.	Assessing climate change impact across KBK region of Odisha	P.K. Mishra Sharad K. Jain Sanjay K. Jain P K Bhunya	2 years (4/13-3/15) **New study**	NIH

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD) 2013-14

S.N.	Title of Project/Study, Study Team, Start/Completion Dates	Status and Recommendations/Suggestions
1.	Recession Flow Analysis for Evaluation of Spring Flow in Indian Catchments Team: Ravindra V. Kale (PI), V. C. Goyal DOS: Apr 2011; DOC: Mar 2013 Extended for 6 months (up to Sep 2013)	Status: Ongoing study 1. r S N Rai mentioned exploring the use of Basel functions 2. r H Kulkarni suggested hydro-geological classification of springs; analysis of variability of spring flows based on slopes, dip/escarpment 3. r Ravi Chopra suggested use of typologies; measures for rejuvenation of springs
2.	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs (**Joint study)** **NIH HQs:** V C Goyal (Leader) Omkar Singh Ravindra V. Kale **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu, RC-Kakinada, RC-Sagar, CFMS-Guwahati, CFMS-Patna DOS: Apr 2012; DOC: Mar 2015	Status: Ongoing study No specific comments.
3.	Action Research for Water Conservation and Management in Selected Village (s) in Hardwar District (Uttarakhand) Team: Omkar Singh, V.C. Goyal and C.K. Jain DOS: Apr 2013; DOC: March 2015	Status: New study No specific comments.

The Working Group noted the progress of the studies undertaken by all divisions. Dr. S.K. Jain, Scientist F & Head, WRS Division presided over the proceeding of the working group on 2nd day and thanked the members for their valuable contributions during deliberations in the Working Group meeting.

The meeting ended with vote of thanks to the Chair.

ANNEXURE-I

List of Working Group Members attended the 38th WG meeting

1.	Er. R.D. Singh, Director, NIH	Chairman
2.	Dr. S.K. Jain, Sc. F & Head WRS Division, NIH	Member
3.	Dr. R C Jain, Regional Director, CGWB, Dehradun	Member
4.	Sh. Sanjiv K. Sharma, Director, GSI, New Delhi	Member
5.	Dr. R.D. Deshpande, PRL, Ahmedabad	Member
6.	Dr. S.N. Rai, CSIR-NGRI, Hyderabad	Member
7.	Dr. N.B. Narasimha Prasad, CWDRM, Kozhikode	Member
8.	Dr. S.K. Bartarya, WIHG, Dehradun	Member
9.	Dr. Kireet Kumar, GBPIHED, Almora	Member
10.	Dr. U.Saravana Kumar, BARC, Mumbai	Member
11.	Dr. R.K. Goyal, CAZRI, Jodhpur	Member
12.	Sh. Niladri Naha, State Water Invest. Dir., Kolkata	Member
13.	Er. R K Khanna, Chief Engineer (Retd.), CWC, New Delhi	Member
14.	Sh. N.K. Sharma, IRI, Roorkee	Member
15.	Dr. M.Perumal, IIT, Roorkee	Member
16.	Dr. Himanshu Kulkarni, ACWADAM, Pune	Member
17.	Sh. Kaushlendra, Bihar	Member
18.	Sh. Anshuman, TERI, New Delhi	Member
19.	Dr. Ravi Chopra, PSI, Dehradun	Member
20.	Dr. N.C. Ghosh, Sc. F & Head GWH Division, NIH	Member
21.	Dr. C.K. Jain, Sc. F & Head EH Division, NIH	Member
22.	Sh. C.P. Kumar, Sc. F & Head HI Division, NIH	Member
23.	Dr. V.C. Goyal, Sc. F & Head RMO Division, NIH	Member-Secretary

Scientists from National Institute of Hydrology, Roorkee

1. Dr. S. K. Singh, Sc. F
2. Dr. Sanjay Jain, Sc.F
3. Dr. Avinash Agarwal, Sc.F
4. Dr. J.V. Tyagi, Sc.F
5. Dr. Sudhir Kumar, Sc.F
6. Dr. M.K. Goel, Sc.F
7. Smt. D.Chalosgaonkar, Sc.F
8. Dr. D.S. Rathore, Sc.F
9. Dr. A.K. Lohani, Sc.F
10. Dr. R.P. Pandey, Sc.F
11. Er. Omkar Singh, Sc.E
12. Dr. P.K. Bhunya, Sc.D
13. Dr. S.P. Rai, Sc.D
14. Dr.A R Senthil Kumar, Sc.D
15. Dr. Anupama Sharma, Sc.D
16. Dr. Sanjay Kumar, Sc.D
17. Dr. Surjeet Singh, Sc.D
18. Dr. Renoj J. Thayyen, Sc.D
19. Smt. Archana Sarkar, Sc.C
20. Dr. Manohar Arora, Sc.C
21. Sh. P.K. Garg, Sc.B
22. Sh.Rajan Vatsa, Sc.B
23. Dr. Ravindra Vitthal Kale, Sc.B
24. Sh. J.P. Patra, Sc.B
25. Sh. Sumant Kumar, Sc.B
26. Dr. Rajesh Singh, Sc.B
27. Sh. L.N. Thakural, Sc.B
28. Mrs. Shashi Poonam, Sc.B
29. Sh. P.K. Mishra, Sc.B

ANNEXURE – B

Division-wise Work Programme

ENVIRONMENTAL HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. C K Jain	Scientist F & Head
2	Dr. (Mrs.) Rama Mehta	Scientist D
3	Dr. M K Sharma	Scientist C
4	Dr. Rajesh Singh	Scientist B
5	Smt. Babita Sharma	RA
6	Smt. Bina Prasad	RA

NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्टा मयोभुवः

Work Programme for the Year 2013-14

S.No.	Study	Study Team	Duration
Internal Studies (Continuing)			
1.	Assessment of Water Quality in Hindon River Basin	M. K. Sharma (PI) Omkar Singh Rakesh Goel Dayanand	3 Years (11/11-10/14) Status: **Completed**
2.	Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas	Rajesh Singh (PI) Dayanand	2 Years (04/11-03/13) Extended for 6 months upto Sep. 2013 Status: Not completed
3.	Applications of Nanotechnology in Water Sector	C. K. Jain (PI) Dinesh Mohan (JNU) Babita Sharma	1 Year (04/13-03/14)
4.	Ground Water Quality Mapping and Surveillance for Safe Water Supply in District Hardwar and Dehradun, Uttarakhand	C. K. Jain (PI) Rama Mehta S. K. Sharma Yatveer Singh Babita Sharma	1 Year (04/13-03/14)
5.	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) C. K. Jain	1 Year (04/13-03/14)
6.	*State-of-the-art Report on Water Quality Modelling for Each Major River and Aquifer	N. C. Ghosh (PI) M. K. Sharma	6 Months (04/13-09/13) Status: **Completed**
Proposed New Studies			
7.	Environmental Flow Assessment of Hemavathi River in Karnataka	D. G. Durbude (PI) C. K. Jain	2 years (04/13-03/15)
8	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier	M. K. Sharma (PI) C. K. Jain Renoj Thayyan Manohar Arora Naresh Saini Jatin Malhotra Rakesh Goyal	3 years (10/13-09/16)
Consultancy Project			
1.	Pilot Study on Ground Water Pollution in Hindon - Kali - Krishini River Catchment in Western Uttar Pradesh	C. K. Jain (PI) M. K. Sharma Rajesh Singh Babita Sharma Rakesh Goyal Daya Nand	6 Months 12/12-05/13 Status: **Completed**

*The study was proposed as per the action plan suggested by MoWR under its National Water Mission on Climate Change.

Mass Awareness Programmes Organized

S.No.	Activity	Venue	Date
1.	Mass Awareness Programme on 'Water Conservation and Water Quality'	Village Sultanpur (Haridwar)	8th Feb. 2013
2.	Mass Awareness Programme on 'Water Conservation and Water Quality'	Village Ibrahimpur (Haridwar)	9th Feb. 2013
3.	Mass Awareness Programme on 'Water Conservation and Water Quality'	Village Kasampur (Haridwar)	2nd Mar. 2013
4.	Mass Awareness Programme on 'Water Conservation and Water Quality'	Village Matlabpur (Haridwar)	4th May 2013
5.	Mass Awareness Programme on 'Water Conservation and Water Quality'	Village Banjarwala (Haridwar)	25th May 2013
6.	Mass Awareness Programme on 'Water Conservation and Water Quality'	Village Gumaniwala (Dehradun)	28th July 2013
7.	Mass awareness programme on 'Water Conservation and Water Quality'	Village Pitthuwala (Dehradun)	31st Aug. 2013
8.	Mass Awareness Programme on 'Water Conservation and Water Quality' for Panchayati Raj Institutions	NIH, Roorkee	5th Oct. 2013

Competitions Organized During Water Conservation Year - 2013

S.No.	Event/Competition	Venue	Date
1.	Debate Competition on the theme Water Conservation for School Children of Class IX-XII	NIH, Roorkee	19th Sep. 2013
2.	Essay Competition on Water Conservation and Water Quality for School Children of Class VI-VII	NIH, Roorkee	20th Sep. 2013
3.	Drawing Competition on Water Conservation for School Children of Class III-V	NIH, Roorkee	23rd Sep. 2013
4.	Quiz Competition on Water Conservation and Water Quality for Women Participants of Degree Colleges	NIH, Roorkee	24th Sep. 2013

Study – 1

1. Title of the Study: **Assessment of Water Quality in Hindon River Basin**

2. Study Group:

Project Investigator Dr. M. K. Sharma, Sc. 'C'
Co-Investigator Sri. Omkar Singh, Sc. 'E'
Scientific/Technical Staff Sri. Rakesh Goyal, Tech. Gr. I Sri. Dayanand, Tech. Gr. II

3. Type of Study: Internal

4. Nature of Study: Water Quality and Human Health

5. Date of Start: Nov. 2011

6. Scheduled Date of Completion: Oct. 2014

7. Duration of the Study: 3 years

8. Study Objectives:

i) Monitoring and assessment of water quality of Hindon River
ii) Examining the suitability of ground water in the vicinity of River Hindon for various designated uses
iii) Characterizing different point source contributing River Hindon
iv) To estimate rate of re-aeration and de-oxygenation coefficients in different reaches of Hindon River
v) To estimate downstream DO deficit in different stretches of river using Streeter-Phelps oxygen sag equation
vi) Explore possible remedial measures for improvement of river water quality

9. Statement of the Problem:

The River Hindon is subjected to varying degree of pollution caused by numerous untreated and/or partially treated waste inputs of municipal and industrial effluents. The main sources of pollution in River Hindon include municipal and industrial (sugar, pulp and paper, distilleries etc.) wastes from Saharanpur, Muzaffarnagar and Ghaziabad urban areas. The water quality of the River Hindon gets further deteriorated due to confluence of River Kali and River Krishni. The river is highly influenced due to heavy metals, pesticides, which enter the river system, by direct discharges of municipal and industrial effluents and surface runoff. These toxic pollutants will ultimately reach the ground water and will enter in the food chain posing a threat to human health because of their carcinogenic nature. The amount of dissolved oxygen (DO) in water is one of the most commonly used indicators of a river's health. As DO drops below 4 mg/L, the forms of life that can survive, begin to reduce and it is essential to estimate DO in different reaches of the river.

In view of these facts, assessment of the present status of surface water quality by estimating DO deficit in different stretches of the river Hindon and ground water quality in the Hindon River Basin will be carried out.

10. Approved Action Plan / Methodology:

i) Sampling of River Hindon and point sources contributing to river and ground water sources in the vicinity of the river in summer, monsoon and winter seasons.

ii) Analysis of the samples for Physico-chemical parameters, Bacteriological parameters, Toxic (Heavy) Metals and Pesticides.

iii) Processing of data for different seasons as per BIS and WHO standards to examine the suitability of surface water and ground water for drinking purpose and irrigation purpose on the basis of total soluble salts, SAR, RSC.

iv) Classification of water using Piper trilinear diagram, Durov plots, Chadha's diagram, U S Salinity Laboratory Classification and Gupta Classification.

v) Identification of degraded water quality locations using spatial distribution map.

vi) Identification of degraded water quality stretches of the River Hindon using Water Quality Index.

vii) Rate of re-aeration in different stretches of the Hindon River would be determined using equation given by O' Connor and Dobbins (1958), $k_r = (3.9u^{1/2})/(H^{3/2})$, where, u is average stream velocity (m/s) and H is average stream depth (m).

viii) The de-oxygenation rate constant (k_d) is often assumed to be same as the (temperature adjusted) BOD rate constant (k) obtained in standard laboratory BOD test (typical values for the BOD rate constant k at 20 ^oC in accordance with Davis and Cornwell (1985) is $k = k_{20}\theta^{(T-20)}$.

ix) Finally, the estimation of downstream DO deficit in different stretches will be carried out using Streeter-Phelps oxygen sag equation,
$D = (k_d L_0/k_r - k_d)(e^{-kd.t} - e^{-kr.t}) + D_0 e^{-kr.t}$ (Streeter and Phelps, 1925)
Where D = Dissolved oxygen deficit (DO_s-DO), DO_s=Saturated value of dissolved oxgen, DO=Actual dissolved oxygen at a given location in the river, k_d=de-oxygenation rate constant (day^{-1}), L_0=initial BOD of the mixture of stream water and wastewater (mg/L), K_r=re-aeration constant ($time^{-1}$), t=elapsed time between discharge point and distance x downstream (x/u), u=stream speed.

11. Timeline:

S. No.	Major Activities	2011-12		2012-13				2013-14				2014-15	
		3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.
1.	Literature survey												
2.	Reconnaissance Survey of the Study Area												
3.	Field visit, sampling and analysis												
4.	Analysis and processing of data												
5.	Report preparation												

12. Objectives and achievement during last six months:

Objectives	Achievements
Analysis and processing of the data	i) Collected samples have been analysed for pesticides. ii) Processed the river water quality and ground water quality data using Water Quality Index. iii) The processing of required data and variables for estimation of DO deficit has been carried out for different stretches of the Hindon River using Microsoft Excel spread sheet.

13. Recommendation / Suggestion: None

Recommendation / Suggestion	Action Taken
Dr. N. B. Narasimha Prasad commented that NIH being an apex Institute, it should take-up studies on some new aspects. Dr. S. K. Jain, Director in-charge also suggested to think of some innovative elements in the study.	Study is being concluded in October, 2013.

14. Analysis & Results:

i. The concentration of α-BHC, γ-BHC and Methoxychlor were detected in few ground water samples of the study area, which may be attributed to extensive use of these pesticides in agricultural practice in the study area, which might have leached to ground water system.

ii. Water quality Indices for water quality at different sites of river Hindon in pre- and post-monsoon seasons were calculated and are given in Table 1. The water quality of river Hindon at all sites in both season was found to be bad.

Table 1. Water Quality Index and Quality of River Water

River Site	Location	Pre-monsoon		Post-monsoon	
		WQI	Water Quality	WQI	Water Quality
RH-1	Kapasa	25.76	Bad	32.20	Bad
RH-2	Nanandi	34.40	Bad	32.20	Bad
RH-3	Sadauli Hariya	35.92	Bad	35.92	Bad
RH-4	Maheshpur	Dry	-	32.48	Bad
RH-5	Charthawal	Dry	-	34.82	Bad
RH-6	Chandheri	Dry	-	32.52	Bad
RH-7	Atali	32.48	Bad	40.26	Bad
RH-8	Barnawa	65.28	Medium	40.16	Bad
RH-9	Daluhera	27.64	Bad	42.28	Bad
RH-10	Surana	26.54	Bad	28.30	Bad
RH-11	Mohannagar	38.68	Bad	41.36	Bad

iii. Water quality indices for different ground water sources in Hindon river basin were calculated for pre- and post-monsoon season and type of water was classified and

most of the ground waters fall between good to excellent type. In post-monsoon season, the quality of ground water was observed to be improved.

iv. The processing of required data and variables for estimation of DO deficit on the basis of Streeter-Phelps oxygen sag equation have been carried out for different stretches of the Hindon River using Microsoft Excel spread sheet. Accordingly, DO deficit for different stretches of the river is under progress.

15. End Users / Beneficiaries of the Study: Policy makers and planners of State Government and common people of the affected areas.

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: None

18. Lab facilities used during the study: Water Quality Laboratory (NIH)

19. Data procured or generated during the study: Surface and ground water quality data and discharge data of the river Hindon basin.

20. Study Benefits / Impacts:

i) Ground water quality and surface water quality data
ii) Identification and characterization of point sources
iii) Rate of re-aeration, de-oxygenation coefficients and DO deficit in different stretches of the Hindon River

21. Involvement of end users/beneficiaries: Local people

22. Specific linkage with Institution and /or end users / beneficiaries: None

23. Shortcoming/Difficulties: No

24. Future Plan: None.

Study – 2

1. Title of the Study: **Development of low cost media for fluoride removal from drinking water of fluoride affected areas.**

2. Study Group:

Project Investigator Dr. Rajesh Singh, Sc. 'B'
Scientific/Technical Staff Sri. Dayanand, Tech. Gr. II

3. **Type of Study**: Internal

4. **Nature of Study:** Technology Development

5. **Date of start:** April 2011

6. **Scheduled date of completion:** Sep. 2013

7. **Duration of the Study:** 2.5 years

8. **Study Objectives:**

i) Development of low cost media for removal of fluoride from drinking water.
ii) Establishing the mechanism involved in removal of fluoride.
iii) Establishing the capacity of media for fluoride removal.

9. **Statement of problem:**

Fluoride is an essential element for human being as it helps in normal mineralization of bones and formation of dental enamel. At the same time, it adversely affects the health of human being when their concentration exceeds the limit of 1.5 mg/L. About 96% of the fluoride in the body is found in bone and teeth. Fluoride is double-edged sword. Ingestion of large amount of fluoride is as harmful as ingestion of its inadequate amount.

In India, more than 76% of the population lives in rural areas. The problem of endemic fluorosis occurs with varying intensity in different parts of the country. Out of the 29 countries known to have excess fluoride in drinking water, the number of people suffering from fluorosis in India is highest in the world, and, with time, the number is increasing rapidly. Excess fluoride ingestion is a major health problem, 20 of the 30 states and union territories in India being endemic for fluorosis.

Therefore, there is a need for development of low cost treatment and remediation technology for fluoride removal.

10. **Approved Action Plan / Methodology**

i) Synthesis of media from bagasse fly ash.
ii) Characterization of media using SEM, TEM, XRD and wet analysis.

iii) Sorption studies.
iv) Column study for application at field scale.
v) Testing of developed media in actual field condition.

11. Timeline:

S.No.	Major Activities	2011-12				2012-13			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1	Literature Survey								
2	Development of media								
3	Characterization								
4	Adsorption studies / model evaluation								
5	Kinetic & thermodynamic studies								
6	Field trials								
7	Report preparation								

12. Objectives and achievement during last six months

Objectives	Achievements
Development of media and characterization	Media synthesized from bagasse fly ash. Characterization completed.
Adsorption studies	Adsorption studies completed.
Kinetic & thermodynamic studies	Kinetic and thermodynamic studies completed
Column Study	Column studies under progress
Field Trials	Batch study conducted
Report Preparation	Interim report prepared and submitted

13. Recommendation / Suggestion

Recommendation / Suggestion	Action Taken
Dr. R. D. Deshpande suggested carrying out column studies for longer duration after exhaustion of media to understand the leachability behaviour of the media and pointed out that in case of any leaching, this would be more damaging to the environment.	Extended run after exhaustion of media carried out.
He also advised to use non synthetic means such as pottery, brick clay etc. for de-fluoridation.	This will be taken up as separate study.

14. Analysis & Results

- Literature survey on low cost treatment technologies based on fly ash indicates that most of the research work has been carried out with coal fly ash and bagasse fly ash for contaminant removal. However, attempt to synthesize zeolite based media

from bagasse fly ash is limited. Till date, zeolite based media synthesized from bagasse fly ash has not been utilized for fluoride removal.

- Fluoride specific zeolite based media synthesized from bagasse fly ash.
- Characterization of the synthesized media completed.
- Adsorption studies completed.
- Column studies under progress.

15. End Users / Beneficiaries of the study: Common people of the affected areas

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: None

18. Lab facilities used during the study: Water Quality Laboratory (NIH)

19. Data procured or generated during the study: None

20. Study Benefits / Impacts

Measurable indicators	**Achievements**
Development of new product	Completed
Solution of identified problem	In progress

21. Involvement of end users/beneficiaries: Local people of the affected regions.

22. Specific linkage with Institution and /or end users/beneficiaries: Nil

23. Shortcoming/Difficulties: No

24. Future Plan:

Leaching of fluoride from media was observed when de-mineralized water passed through the column after over exhaustion. This was possibly due to over exhaustion as well as feed solution with higher concentration of fluoride (20 mg/L). Keeping in view of the same, some more trials with different concentration of fluoride will be carried out. Moreover, some changes in matrix will be carried out to reduce the leaching of fluoride after sorption. Hence, six months extension is required**.**

Study - 3

1. Title of the Study: Applications of Nanotechnology in Water Sector

2. Study Group:

Project Investigator(s) Dr. C. K. Jain, Sc. 'F' Dr. Dinesh Mohan (JNU)
Co-Investigator(s) Smt. Babita Sharma, RA

3. Type of Study: Internal

4. Nature of Study: Technology Overview Document

5. Date of Start: April 2013

6. Scheduled Date of Completion: March 2014

7. Duration of the Study: One Year

8. Study Objectives:

i) To develop a white paper examining potential environmental applications and implications of nanotechnology in water sector
ii) To examine possible impacts of nanomaterials and nanoproducts on human health and the environment.
iii) To promote the use of this new, exciting technology in a manner that protects human health and the environment.

9. Statement of the Problem:

The availability and access to safe drinking water, especially amongst the poor is an issue that is accelerating with time. Many water sources are contaminated with both biological and chemical pollutants such as arsenic, fluoride, etc. New problems like organic contamination (pesticides, insecticides, etc.) and increasing salinity are affecting water sources extensively. Bacterial contamination in surface water and at points of use is a major cause of concern.

Great strides have been made in applying nanotechnology in varying degrees of complexity in several fields – from space travel to cosmetics. Nanotechnology for safe water is an area that is being looked at globally and is also a priority concern in India. While there are several types of nanotechnology that are relevant to addressing safe water, there are some that may be more appropriate, affordable and sustainable for use among the poor. Nanotechnologies can provide solutions to alleviate water problems, both in terms of detection and removal of contaminants. Also since small amounts of nonmaterial are used for purification, costs and waste generation are low, providing an effective and affordable water treatment solution to the poor.

10. Approved Action Plan / Methodology:

i) Literature survey through international publications (research papers / reports)
ii) Compilation / evaluation of case studies
iii) Evaluation of benefits / drawbacks of nanotechnology and its application in water sector
iv) Report preparation

11. Timeline:

S.No.	Major Activities	2013-14			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1.	Literature survey (research papers / reports)				
2.	Compilation / evaluation of case studies in water sector				
3.	Evaluation of the benefits / drawbacks of nanotechnology				
4.	Report preparation (Draft)				
5.	Brain Storming Session / Final Report				

12. Objectives and achievement during last six months:

Objectives	Achievements
Literature survey (research papers / reports)	In progress
Compilation / evaluation of case studies in water sector	In progress

13. Recommendation / Suggestion: Nil

Recommendation / Suggestion	Action Taken

14. Analysis & Results: Based on the literature survey, the following scheme of chapterization has been finalized and the report is under writing stage under the following heads.

1. INTRODUCTION
2.0 USES OF NANOTECHNOLOGY
- 2.1 Nano Films
- 2.2 Nano Tubes
- 2.3 Drug Delivery Techniques
- 2.4 Nanoscale Transistors
- 2.5 Water Filtration Techniques

3.0 NANOTECHNOLOGY IN WATER SECTOR
- 3.1 Nanofiltration and Desalination
- 3.2 Nanocatalysts and Magnetic Nanoparticles
- 3.3 Nanosensors

4.0 RECENT CASE STUDIES
5.0 RISKS OF NANOTECHNOLOGY
    5.1 Environmental Risks
    5.2 Health Risks
6.0 OPPORTUNITIES AND CHALLENGES
7.0 CONCLUSIONS AND RECOMMENDATIONS
8.0 REFERENCES

Working Group may kindly consider and suggest if any changes/modifications are required to be made.

15. End Users / Beneficiaries of the Study: Academic and research institutions engaged in R&D in nanotechnology

16. Deliverables: Technical Report / Research Papers

17. Major items of equipment procured: NA

18. Lab facilities used during the study: NA

19. Data procured or generated during the study: NA

20. Study Benefits / Impacts:

Measurable Indicators	**Achievements**

21. Involvement of end users/beneficiaries: Academic and research institutions engaged in R&D in nanotechnology

22. Specific linkage with Institution and / or end users / beneficiaries: No

23. Shortcoming/Difficulties: No

24. Future Plan: The proposed study will be completed as per schedule i.e. March 2014 and further future plan will be worked out after completion of the proposed study report.

Study – 4

1. Title of the Study: Ground Water Quality Mapping and Surveillance for Safe Water Supply in District Hardwar and Dehradun, Uttarakhand

2. Study Group:

Project Investigator Dr. C. K. Jain, Sc. 'F'
Co-Investigators Dr. Rama Mehta, Sc. 'D' Dr. S. K. Sharma, Sc. 'B' Sri. Yatveer Singh, PRA Smt. Babita Sharma, RA

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of Start: April 2013

6. Scheduled Date of Completion: March 2014

7. Duration of the Study: One Year

8. Study Objectives:

i) To examine the quality of ground water for drinking and irrigation purpose
ii) To identify degraded water quality zones for quality improvement
iii) To characterize ground water quality using different classification schemes
iv) To suggest water safety plan for District Hardwar and Dehradun
v) To organize mass awareness programmes on water related issues

9. Statement of the Problem:

Nearly 80% of the sewage generated in India flows untreated into its rivers, lakes and ponds, turning the water sources too polluted to use. The end result: ground water in almost the entire country has nitrate levels higher than the prescribed levels – a result of sewage leaching into ground water aquifers. Indian cities produce nearly 40,000 millions litres of sewage per day, enough to irrigate 9 million hectares and barely 20% of this is treated. In most cities, the sewage simply mixes into open drains, polluting water sources. Untreated sewage is seeping into water resources leading to pollution of water resources. Almost half of the urban population still depends upon ground water sources for drinking, cooking and bathing which puts them at direct risk from polluted water (Source: The Times of India, 6th March 2013).

The major issues in the Rural Water Supply sector are lack of sustainability of drinking water sources and systems. As a consequence, availability of drinking water both in terms of adequacy and quality on a sustainable basis has become a major challenge. Water quality has become a major issue as ground water table goes down further. The levels of

natural contaminants such as fluoride and arsenic and man-made chemical pollutants such as metals, pesticides and insecticides are high and still rising. The biological contamination of large number of drinking water sources is a serious problem primarily due to prevalent open defecation and insanitary conditions around the drinking water sources in rural India. After introduction of rural drinking water supply and basic sanitation programme in the villages, the prevalence of water borne diseases such as diarrohea, cholera, etc. has decreased, but the incidence is still relatively high in some parts of the country. However, it is seen that at the implementation / field level, rural water supply programme is not integrated with sanitation, nor is it integrated or coordinated with primary health care and other related programmes. The new guidelines seek to remove this handicap by formulating a coordinating mechanism through convergence of related programmes at the field level e.g. National Rural Health Mission (NRHM), National Rural Employment Guarantee Scheme (NREGS) etc. The outcome of the study will be forwarded to MoWR for proper implementation through NHRM and NREGS.

10. Approved Action Plan / Methodology:

i) Sampling of ground water in pre- and post-monsoon seasons based on habitations
ii) Analysis of physico-chemical parameters: pH, EC, TDS, Alkalinity, Hardness, Major Cations (Na, K, Ca, Mg), Major Anions (HCO_3, Cl, SO_4, NO_3), Minor Ions (F, PO_4, B etc.)
iii) Analysis of bacteriological parameters: Total & Faecal Coliform
iv) Analysis of metals ions: Fe, Mn, Cu, Ni, Cr, Pb, Cd, Zn, As, Hg.
v) Data processing: Data will be processed as per BIS and WHO standards, ionic relationships will be developed and water types will be identified. Spatial distribution maps will be prepared using GIS to identify degraded water quality zones for quality improvement. Suitability of ground water for irrigation purpose will be studied on the basis of total soluble salts, SAR, RSC and B content. Classification of water will be made using Piper trilinear diagram, Chadha's diagram and U.S. Salinity Laboratory classification.

11. Timeline:

S.No.	Major Activities	2013-14			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1.	Collection of information (Water supply)				
2.	Field monitoring survey / Sample collection	**Pre**		**Post**	
3.	Laboratory investigations				
4.	Data processing / analysis				
5.	Report preparation				
6.	Mass Awareness Programmes*				

* As per the directions of MoWR

12. Objectives and achievement during last six months:

Objectives	Achievements
Sampling of ground water during pre-monsoon season	Completed for Bahadrabad Block as per the approval
Analysis of physico-chemical and bacteriological parameters	Completed for Bahadrabad Block
Analysis of metals ions on ICP-MS	Completed for Bahadrabad Block
Data processing	Under progress

13. Recommendation / Suggestion: Nil

Recommendation / Suggestion	Action Taken

14. Analysis & Results:

Pre-monsoon sampling from 50 ground water sources covering shallow and deeper aquifers have been completed for Bahadrabad Block and samples have been analyzed for physico-chemical and bacteriological parameters using standard procedures. Metal ions have been analyzed on ICP-MS. Data has been compiled and is being processed as per BIS and WHO standards to see the suitability of ground water for drinking and irrigation purposes, ionic relationships are being developed and water types are being identified. Attempt will be made to classify the ground water on different classification schemes, viz., Piper trilinear diagram, Chadha's diagram and USSL classification.

15. End Users/Beneficiaries of the Study: Common people of the affected areas.

16. Deliverables: Technical Report / Research Papers

17. Major item of equipment procured: NA

18. Lab facilities used during the study: WQL of NIH & IIC of IITR

19. Data procured or generated during the study: Ground Water Quality Data of Bahadrabad Block in District Hardwar

20. Study Benefits / Impacts:

Measurable Indicators	Achievements

21. Involvement of end users/beneficiaries: Local people

22. Specific linkage with Institution and/or end users / beneficiaries: No

23. Shortcoming/Difficulties: Required approvals for field visits could not be granted due to which field/laboratory work could not be completed as contemplated and the

study had to be limited to Bahadrabad Block in District Hardwar only as per the approval for field work.

24. Future Plan:

The study will be completed for Bahadrabad Block in District Hardwar as per schedule i.e. March 2014.

Study – 5

1. **Title of the Study:** Water Quality Modeling using Soft Computing Techniques

2. **Study Group:**

Project Investigator Dr. Rama Mehta, Sc. 'D'
Co-Investigator Dr. C. K. Jain, Sc. 'F'
Ms. Anju Chowdhary, SRA

3. **Type of Study:** Internal

4. **Nature of Study:** Applied Research

5. **Date of Start:** April 2013

6. **Scheduled Date of Completion:** March 2014

7. **Duration of the Study:** One Year

8. **Study Objectives:** To develop a model for assessment of water quality using soft computing techniques.

9. **Statement of the Problem:**

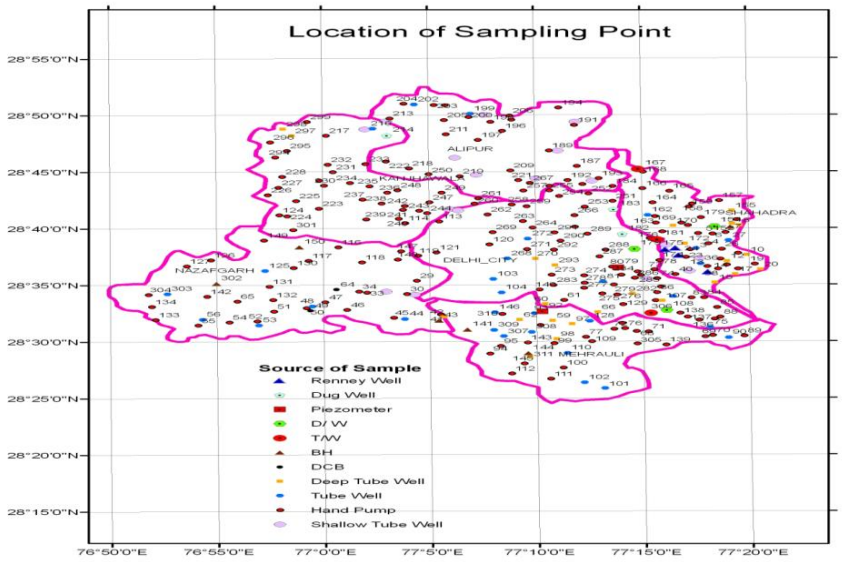
Water quality parameters have been taken as input data to develop a model for assessment of the quality of water using conventional and soft computing techniques.

10. **End Users/Beneficiaries of the Study:** Policy makers and planners of State Government and common people of the affected areas.

11. **Whether study is a new study/extension of previous studies:** start in April 2013.

12. **Baseline data/information on the study area and results of previous studies:**

Study area: Samples have been collected from entire Delhi area, comprising all the six blocks viz. Alipur, Khanjhawala, Najafgarh, Mehrauli, City and Shadara. The ground water sampling locations have been depicted as below:



The ground water sampling locations in all six blocks in NCR region.

Data Availability: Total 303 ground water samples were collected and analyzed for water quality parameters, viz., pH, EC, TDS, CO_3, HCO_3, Cl , SO_4, NO_3, F, PO_4, Ca, Mg, Na and K in stationary laboratories through Central Ground Water Board, Chandigarh and Central Pollution Control Board, Delhi. This data has been collected through their published report and some parameters are being used for the analysis. All six block boundaries are drawn in GIS. Each block is showing all sampling locations with different means.

13. Methodology:

Water quality indices (WQI) aim at giving a single value to the water quality of a source, which translates the list of constitutes and their concentrations present in a sample in a single value. One can compare different samples for quality on the basis of the index value of each sample. The use of WQI has been strongly advocated by agencies responsible for water supply and control of water pollution. Following methods will be used to develop the model and assessment of water quality.

Empirical Method: WQI formed with n parameters assigned with different weights. The unit weight (W_i) for each parameter is calculated as:

$$W_i \equiv \frac{1}{n}\sum_{i=1}^{n} w_i$$

Each sub-index $(SI)_I$ is given by $(SI)_I = q_i\, w_i$ when q_i is the quality rating of the i^{th} parameter then

$$WQI = \sum_{i=1}^{n} q_i W_i$$

Values of WQI are formulated through empirical method with equal and different weights of the parameters. The index score is obtained with a linear sum aggregation function.

Canadian Water Quality Guidelines: Although there have been a variety of attempts to create such a water quality index, the most successful attempt to date appears to be the index development by the Canadian council of Ministry of Environment, (CCME WQI). This index has been adopted as water quality index of the sample.
This index is based on a combination of three factors:

1. the number of variables whose objectives are not met, (Scope)
2. the frequency with which the objectives are not met, (frequency) and
3. the amount by which the objectives are not met, (amplitude).

These are combined to produce a single value (between 0 to 100) that describes water quality. Once the WQI value has been determined, water quality is ranked by relating it to one of the following categories:

Excellent: (WQI Value 90-100) – water quality is protected with a virtual absence of threat or impairment, conditions very close to natural or pristine levels.
Very Good: (WQI Value 80-89) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Good: (WQI Value 60-79) – water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal: (WQI Value 30-59) – water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor: (WQI Value 0-29) – water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Fuzzy Inference System (FIS): The process of fuzzy inference involves all of the pieces that are described as membership functions, fuzzy logic operators and if-then rules. It is the process of formulating the mapping from a given input to an output using fuzzy logic. This mapping provides a basis from which decision can be made. There are two types of fuzzy inference systems that can be implemented in the fuzzy logic toolbox: Mamdani type and Takagi – Sugeno type.

For fuzzification of input data, the gray values (minimum and maximum values of the premises) have been divided into different classes. Different type of membership functions have been tried for all input parameters. Although membership functions can have any number of categories, but 4-5 categories per variable seems to be adequate. All the crisp values of premises have their membership values within their specified categories. Now these fuzzified values developed a database for the fuzzy rules.

14. Timeline:

S.No.	Major Activities	2013-14			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1.	Literature review and data analysis				

2.	Model development with application of soft computing methods				
3.	Testing, evaluation and comparison with conventional methods				
4.	Analysis of results and report writing				

15. Deliverables: Technical Reports / Research Papers

16. Proposed measurable indicator: improvement in existing technique / technology using soft computing techniques

17. Involvement of end users/beneficiaries: No

18. Specific linkage with Institution and/or other NGOs: CPCB / CGWB / NEERI

19. Major items of equipment needed: NA

Study – 6

1. Title of the Study: **State-of-the-art Report on Water Quality Modelling for River and Aquifer**

2. Study Group:

Project Investigator Dr. N. C. Ghosh, Sc. 'F'
Co-Investigator Dr. M. K. Sharma, Sc. 'C'

3. Type of Study: Referred by MoWR

4. Nature of Study: Thrust Area- Water Quality Modelling

5. Date of Start: April 2013

6. Scheduled Date of Completion: Sep. 2013

7. Duration of the Study: 6 months

8. Study Objectives: To prepare a state of art report on Water Quality Modelling

9. Statement of the Problem:

Water quality modelling is an attempt to simulate the behaviour of natural surface and ground water and hydrologic system by defining the essential feature of the system in some physical manner. It provides the idea of status of pollution at downstream sites using the water quality and hydrological data of upstream site and can be used for prediction purposes in space and time in case of surface water. Groundwater quality modelling can be used to simulate the behaviour of complex aquifers including the effects of irregular boundaries, heterogeneity and different processes such as groundwater flow, solute transport and heat transport. Because of the complexity of hydro geological setup of aquifers and dynamic nature of pollutants and groundwater, groundwater quality modelling is becoming indispensible tool to understand the fate and transport of pollutants in groundwater and to address various groundwater quality problems in space and time. In India, few attempts have been made covering the aspects of surface as well as ground water quality modelling. There is urgent need to carry out these studies in different basins. In view of the above, a state of the art report will be prepared within a period of six months.

10. Methodology:

The report will be prepared covering the following heads by carrying out extensive literature survey:

i) Introduction
ii) Surface water quality modeling – Global and Indian Scenario
iii) Ground water quality modeling – Global and Indian Scenario
iv) Gaps needs to be filled up

v) Concluding Remarks

11. Timeline: 6 months

12. Objectives and achievement during last six months:

Objectives	**Achievements**
To prepare a state of art report on Water Quality Modelling	Draft of river water quality modelling part completed and submitted to Dr. N. C. Ghosh.

13. Recommendation / Suggestion: None

14. Analysis & Results: Extensive literature survey has been carried out to update the information.

15. End Users / Beneficiaries of the Study: Policy makers and planners of State and Central government

16. Deliverables: Technical report

17. Major items of equipment procured: None

18. Lab facilities used during the study: None

19. Data procured or generated during the study: None

20. Study Benefits / Impacts: Status of surface and ground water modelling

21. Involvement of end users/beneficiaries: None

22. Specific linkage with Institution and /or end users / beneficiaries: None

23. Shortcoming/Difficulties: No

24. Future Plan: None.

Study – 7 (New Study)

1. Title of the Study: **Environmental Flow Assessment of Hemavathi River in Karnataka**

2. Study Group:

Project Investigator Dr. Dilip G. Durbude, Sc. 'C'
Co-Investigator Dr. C. K. Jain, Sc. 'F'

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of Start: April 2013

6. Scheduled Date of Completion: March 2015

7. Duration of the Study: 2 years

8. Study Objectives:

i) To study the flow characteristics and bio-diversity of the river
ii) To assess the environmental flow requirement for the river

9. Statement of Problem:

It is prime importance to assess the ecological status of rivers before making any decisions to develop water resources. Making changes to the flow in rivers for water resource development may leads to changes in the diversity of aquatic communities. Species adapted to natural flow regimes will disappear due to change in flow regime. Reducing river flows due to water resources project means less aquatic (fish) and terrestrial life (wildlife) and lowering quality of water. Ignoring the need for environmental flows to keep river ecosystems healthy may do serious and even irreversible damage.

Karnataka state was comfortable position in the power sector till 1972. But, 1973 onwards, there was acute shortage of power. This affects not only industrial development but also the other sectors of economy including agriculture. Hydropower contributes about 63.4% of the Karnataka power system. Due to increasing demand, a large deficit in peak power demand and energy availability, which generate a scope for development of Hydropower. Harnessing the hydropower potential to mitigate the power demand, there is need to develop the number of river flow diversion type hydropower projects. These activities will have adverse impact on the fluvial ecosystem due to changed environmental flow regime on the river bed and river bank ecology. To maintain the health, function and integrity of the river ecosystem through the protection of aquatic organism dwelling in these fluvial ecosystems, an appropriate environmental flow is required. Therefore, the study is proposed to assess the environmental flow requirement of one of important tributary of Cauvery river in Karnataka State.

10. End Users/Beneficiaries of the Study: Karnataka Power Corporation Limited, Karnataka State Irrigation Department, etc.

11. Methodology

i) Data collection/procurement from Water Resource Development Organization (WRDO), Bangalore/Centre Water Commission (CWC), New Delhi
ii) Field survey to study bio-diversity existed in the river ecosystem
iii) Statistical analysis of water quality and flow data
iv) Computation of environmental flow using various methodologies/approaches
v) Recommendation for environmental flow requirement at various stretches of the river

12. Timeline:

S.No.	Major Activities	2013-14				2014-15			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1	Literature Survey								
2	Secondary data collection								
3	Field survey								
4	Procurement of flow data								
5	Preparation of Interim report								
6	Field monitoring programme								
7	Data interpretation using GIS								
8	Computation of EFR								
9	Preparation of Final report								

13. Deliverables: Technical Report & Research Papers

14. Proposed Measurable Indicator: Quantified EFR at various stretches of river

15. Technology Transfer Possibilities: No

16. Involvement of End Users/Beneficiaries: KPCL, Bangalore, Karnataka State Irrigation Department, etc.

17. Specific linkage with Institution and /or Other NGOs: Under identification with the problematic area authorities

18. Major Items of Equipment Needed: WQ Lab facilities of NIH

Study – 8 (New Study)

1. Title of the Study**: Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier**

2. Study Group:

Project Investigator Dr. M. K. Sharma, Sc. 'C'
Co-Investigator Dr. C. K. Jain, Sc. 'F' Dr. Renoj Thayyan, Sc. 'D' Dr. Manohar Arora, Sc. 'C'
Scientific/Technical Staff Sri. Naresh Saini, PRA Sri. Jatin Malhotra, SRA Sri. Rakesh Goyal, Tech. Gr. I Sri. Dayanand, Tech. Gr. II

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of start: Oct. 2013

6. Scheduled date of completion: Sep. 2016

7. Duration of the Study: 3 years

8. Study Objectives:

i) To characterize the seasonal variability of the major-ion chemistry of glacial meltwater.
ii) Chemical characterization of the suspended sediment of Gangotri glacial system
iii) To study Ionic enrichment dynamics of meltwater-glacial sediment interaction
iv) To investigate open and closed system low temperature ionic enrichment process

9. Statement of problem:

Higher level of pollutant load in the lower reaches of River Ganges is as an unresolved problem for the past many decades. There were number of projects launched by the Government of India to address this issue, but failed to achieve the desired result during the past two decades. Contribution of Himalaya rivers originating from snow and glacier fields of higher Himalaya spread across India, Nepal and Tibet, play an important role in controlling the solutes levels in the River Ganges. As these mountain waters with significant amount of snow, glacier meltwaters and rainfall is characterised by low ionic concentrations and play a major role in diluting the high solute load emanating from Ganga plain

catchments. Hence any change in the quality and quantity of the Himalayan tributaries of River Ganga under the climate change regime will impact the quality parameters of River Ganga. Understanding of low temperature solute acquisition processes is therefore very important for assessing the solute acquisition and pollutant loading further downstream. Higher sediment load in the glacier fed streams play a significant role in solute acquisition by its interaction with dilute glacial and snow melt waters. Further downstream, higher sediment load due to anthropogenic activities added another dimension to the problem. As Gangotri glacier is the biggest glacier in the region as well as the source of River Ganga, it is imperative to study the dynamics of solute acquisition by dilute glacier waters in interaction with freshly grinded glacier sediments. Hence this study is conceptualised to build the existing knowledge gap on solute acquisition of glacier melt waters during its transit with high sediment load under prevailing low temperature conditions close to the glacier.

10. End Users / Beneficiaries of the study: Policy makers and planners in water sector.

11. Whether study is a new study/extension of previous studies: New study

12. Baseline data/information on the study area and results of previous studies: NA

13. Methodology:

i) Literature survey through international publications (research papers/ reports)
ii) Reconnaissance survey of Gangotri glacier catchment for site selection.
iii) Collection Suspended sediment samples and meltwater samples from selected sites seasonally.
iv) Chemical analysis for major cations, anions and trace metals in the collected suspended sediment and meltwater.
v) Geochemical analysis of suspended sediments
vi) Study of closed system characteristics and open system dynamics
vii) Dissolution experiments of glacial meltwater-suspended sediment interaction

14. Timeline:

Activity	2013-14		2014-15				2015-16				2016-17	
	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.
Literature survey												
Reconnaissance Survey												
Collection of SS and melt water samples												
Chemical analysis of SS and melt water												
Geochemical analysis of SS												
Open and closed system study												
Dissolution exp. of glacial melt water-SS interaction												
Interim Report												
Final Report												

15. **Deliverables:** Technical Reports/Research Papers

16. **Proposed measurable indicator:** Low temperature chemical process in controlling the solute acquisition during suspended sediment-meltwater interaction

17. **Involvement of end users/beneficiaries:** No

18. **Specific linkage with Institution and /or other NGOs**: No

19. **Major items of equipment needed:** Water Quality Laboratory, NIH

GROUND WATER HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. N C Ghosh	Scientist F & Head
2	Dr. Anupma Sharma	Scientist D
3	Dr. Surjeet Singh	Scientist D
4	Sri Rajan Vatsa	Scientist B
5	Sri Sumant Kumar	Scientist B
6	Ms. Shashi Poonam Indwar	Scientist B
7	Sri Sanjay Mittal	SRA
8	Sri Ram Chandra	RA

WORK PROGRAMME FOR THE YEAR 2013-14

S. No. & Reference Code	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/ NIH/13-14	Estimation of specific yield and storage coefficient of aquifers	Surjeet Singh (PI) N.C. Ghosh (Co-PI) Sumant Kumar	1 year (04/13 – 03/14) **Status**: In progress	NIH
2. NIH/GWD/ NIH/13-14	State-of-the-Art Report on Modeling of Coastal Aquifers Vulnerable to Sea Water Ingress	Anupma Sharma (PI) C.P. Kumar (Co-PI) Rajan Vatsa	1 year (04/13 – 03/14) **Status**: In progress	NIH (Reffered by MoWR)
Sponsored & HP-II Projects				
3. NIH/GWD /HP-II/10-12	Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat.	N. C. Ghosh, Anupma Sharma (PI) C P Kumar (Co-PI) SE (GWRDC, Gujarat), C.K. Jain, Sudhir Kumar D.S. Rathore, M.S. Rao Surjeet Singh, Rajan Vatsa	4 years (10/09 – 12/13) **Status:** In progress	PDS (HP-II)
4. EU-sponsored Project no. 282911	Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India"	N. C. Ghosh (PI), V. C. Goyal, C. K. Jain, Sudhir Kumar,B. Chakravorty A. K. Lohani, Anupma Sharma, Surjeet Singh Sumant Kumar, and Shashi Poonam Indwar	36 months (10/ 11-9/14) **Status:** In progress	European Union under 7^{th} - Framework
5. NIH/GWD/ NIH/11-14	Management of Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)	Sumant Kumar (PI) Rajan Vatsa, N.C. Ghosh C.P. Kumar, Surjeet Singh, Sanjay Mittal	3 years (04/11 – 03/14) **Status:** In progress	Saph Pani Project
6. EU-sponsored Project no. 282911	Flow and Contaminant Transport Modeling of Riverbank Filtration	Shashi Poonam Indwar (PI), N.C. Ghosh Anupma Sharma, Rajan Vatsa	2 ½ years (04/12 – 09/14) **Status:** In progress	Saph Pani Project
Consultancy Projects				
7.	Study of hydrological and hydro-geological aspects of the Jhabua Power Project in Madhya Pradesh to assess water source sustainability	N.C. Ghosh (PI) M.K. Goel, A.K. Lohani, T.R. Nayak S.P. Rai, Surjeet Singh, T. Thomas, Sanjay Mittal	03 months **Status:** In progress	JPL, APIL, Gurgaon
8.	Study of hydrological and hydro-geological aspects of the Korba Power Project in	N.C. Ghosh (PI), A.K. Lohani, S.P. Rai Ravi Galkate, Surjeet	03 months **Status:**	KWPCL, APIL, Gurgaon

	Chhattisgarh to assess water source sustainability	Singh, R.K. Jaiswal Sanjay Mittal	In progress	
9.	Drainage Area Mapping and Hydrological Studies in and around Gurha (W) Block in Kolayat Tehsil of Bikaner District, Rajasthan	A. K. Dwivedi (PI) N.C. Ghosh (PI) Surjeet Singh, Rajan Vatsa, Sumant Kumar S.P. Rai	15 months **Status:** Completed	RSMML. Rajasthan

Outreach activities suggested for the year 2013-2014

1. Brainstorming session on a relevant topic (1/2-day activity with line department and researchers as participants) – one,

Possible topics

- Managed Aquifer Recharge for sustainable groundwater development & management.
- Bank Filtration for sustainable drinking water supply.
- Drinking water source sustainability.

2. Training course on identified topics relevant in the Division (3 to 5 day activity) - two courses.

- Coastal groundwater modelling and management
- Groundwater modelling and management
- Managed aquifer recharge or Artificial Groundwater Recharge
- Conjunctive use of surface water and groundwater.

3. Plan (giving topic, organizations and place, period) for capacity building /training of scientists and staff in the division

- Remote Sensing and GIS application in Groundwater Data Management
- Groundwater Modelling (Flow and contaminant transport)
- Groundwater data measurements, aquifer parameters estimation, and characterization.
- Climate Change versus groundwater resources.
-

1. **PROJECT REFERENCE CODE: NIH/GWD/NIH/13-14**

Title of the Study: Estimation of specific yield and storage coefficient of aquifers

Location Map: Multi-sites data and information will be used.

Statement of the Problem:

The specific yield and the storage coefficient are the two main parameters that play very vital role in any groundwater study. The accuracy of groundwater resource estimation relies on these parameters. Numerous methods are available in literature; however selection of the suitable method and its data requirements under varying range of field conditions is a challenging task. In this context, the present study has been proposed to compile various methods and prepare a state-of-the-art report on the estimation of '*Specific yield*' and '*Storage coefficient*'.

Approved action plan:

- Exhaustive literature review.
- Compilation of various methods suggested by researchers; inter-comparison of methods wherever possible by a set of field data.
- Identification of merits and demerits of each method and suggesting suitable method for varying range of field conditions.
- Preparation of the report.

Timeline and justification for time over runs:

1-6 months: Literature review & data collection.
7-12 months: Inter-comparison, sensitivity analysis of various methods under varying field conditions and accordingly identify suitable methods, and report writing.

Objectives & Achievements:

Compilation and critical appraisal on various methods developed and widely used for estimation of specific yield and storage coefficient.	• Review of various techniques and methods has been completed. • A review note has been prepared.
Preparation of a state-of-the-art report on estimation of specific yield and storage coefficient.	• Will be undertaken during Nov. 2013 –Mar. 2014.

Recommendations/suggestions in previous meetings of Working Group/TAC/GB –

Dr. S.N. Rai and Dr. R.C. Jain had suggested to make a comprehensive review of various methods.

Analysis and Results:

1. Comprehensive review of literature.
2. Merits and demerits of various methods.
3. Data requirements of various methods

Adopters of the results of the study and their feedback:

- State GW Deptts.
- Academic and R&D Institutes.

List of deliverables: State-of-art-report.

Major items of equipment procured: Nil.

Lab facility used under the study: Numerical Groundwater Modeling Unit (NGMU).

Data procured and generated:

- Collection of rainfall, geology, soil information, ground water levels, lithology, well details, etc. are under progress.

Study Benefits: The proposed technical document will help researchers and groundwater professions to have compiled information at one place.

Specific linkages with Institutions and/or end-users/beneficiaries:

- End-users/beneficiaries: Researchers, Groundwater Departments, etc.

Shortcomings/Difficulties, if any: Nil

Future Plan: Submission of Final Report by 30th April, 2014.

2. PROJECT REFERENCE CODE: NIH/GWD/INT/13-14

Title of the study: **State-of-the-Art Report on Modeling of Coastal Aquifers Vulnerable to Sea Water Ingress**

Study objectives:

1. To describe the general hydrogeology of coastal regions in India
2. To characterize water quality problems of coastal regions.
3. To review recent advances in hydro-chemical and solute transport investigations and modeling in areas vulnerable to seawater ingress.
4. To compile investigations and modeling studies undertaken in coastal regions of India.
5. To compile research studies on impact of climate change on water resources of coastal regions.

Specific linkages with Institutions and/or end-users/beneficiaries: The study has emerged as an action suggested by Ministry of Water Resources (MoWR) under its National Water Mission on Climate Change. The report would be utilized by National Water Mission on Climate Change.

Work Done/ Analysis:

1. Literature review under progress
2. One base paper on 'Coastal Aquifer Management Including Use of Hydraulic Barriers for Control of Seawater Ingress' prepared and submitted to MoWR.

List of deliverables (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programs, users interaction workshops)

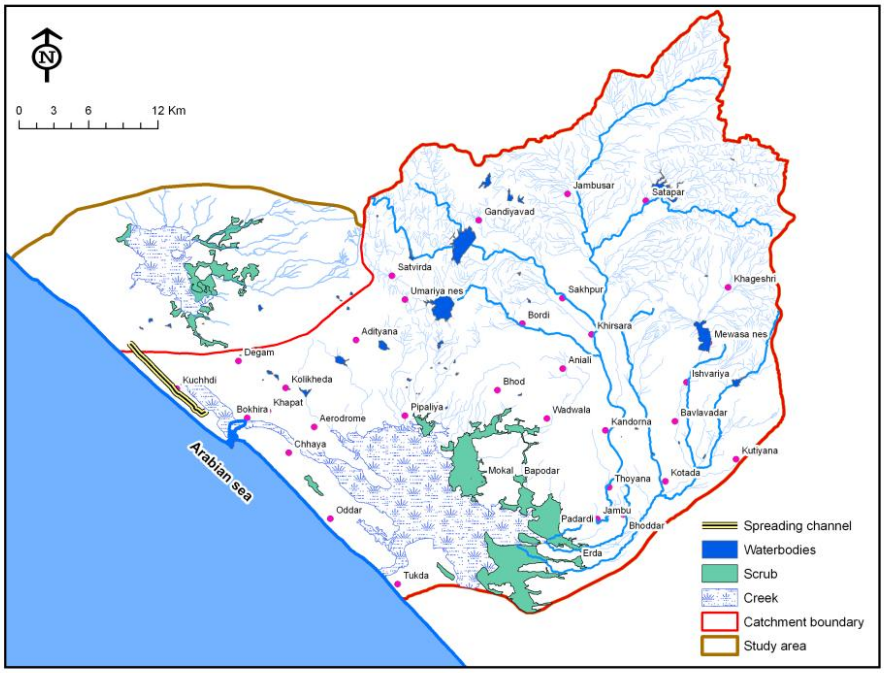
1. Report
2. Review Paper

Future Plan: Submission of Final Report by April 30, 2014.

3. PROJECT REFERENCE CODE: NIH/GWD/HP-II/10-12

Title of the study: **Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat.**

Location map:



Study Area: Minsar River Basin, Coastal Saurashtra, Gujarat

Study objectives:

1. To characterize the various hydrologic components and establish their quantitative inter-relationships in the coastal aquifer system.
2. To identify causes of increasing groundwater salinity and its far reaching consequences on the coastal aquifer system, and to establish the physico-chemical mechanism of mixing of freshwater-saltwater in the coastal aquifer system of Saurashtra region.
3. To simulate the transport of saltwater in the coastal aquifer system through numerical modeling and study impact of existing aquifer management practices on the groundwater regime.
4. To evaluate the impact of anticipated climate change on groundwater recharge and dynamics of coastal aquifer system and suggest suitable remedial measures.
5. Analysis of effect of water quality degradation due to saltwater intrusion on the socio-economic growth.
6. Rollover of project output to State Departments in Gujarat and concerned users in terms of technology transfer of technical know-how gained during the project for implementation of program for sustainable development of coastal groundwater resources.

Statement of the problem:

To investigate the coastal groundwater dynamics and saltwater intrusion phenomenon in the Porbandar District of Coastal Saurashtra.

Approved Action Plan:

1. Collection and monitoring of data and identification of data gaps.
2. Development of thematic maps using remote sensing and GIS.
3. Isotope analysis and water quality assessment.
4. Field tests and geophysical surveys, hydrogeological surveys in study area.
5. Development of hydrological water balance model.
6. Hydrogeochemical/geophysical surveys for 3D mapping and monitoring of freshwater-saltwater interface.
7. Numerical modeling of saltwater transport in the coastal aquifer system.
8. Field experiments for artificial recharge.
9. Evolve guidelines for optimal design of possible remedial measures in terms of pumping policy and artificial recharge.
10. Evaluation of the impact of anticipated climate change on groundwater recharge and dynamics of coastal aquifer system for different scenarios of sea level rise and rainfall events and suggest suitable remedial measures.
11. Analysis of affect of water quality degradation due to saltwater intrusion on the socio-economic growth.
12. Organization of training courses for state departments.

Objectives vis-à-vis Achèvements:

Objectives	Achievements
Literature review	Completed.
Field visits	Three since April 2013.
Data collection	Collection of data about cropping patterns, river stage and water levels in surface water bodies, heavy pumping zones, spreading channel, meteorological data, irrigation and water supply schemes, socio-economic data, coastal belt plantation
Data monitoring	Water level and water quality data monitoring of wells every two months, including creeks and reservoir schemes near coast
Field experiments and Laboratory investigations	- Rock samples collected and under analysis - Relocation of two data loggers - Purging of piezometers; water level recovery observations - Samples for water quality, isotope and bacterial analysis - Measurement of salinity profiles through TLC meter - Geochemical analysis of collected samples
Database preparation	DEM, Geological and hydrogeological setup, Land use, Pump test data, Geochemical data, Water elevations, Water balance
Data analysis	Analysis of satellite data, pump tests, water table and water quality data; Data analysis for infiltration and saturated hydraulic conductivity; Water balance computations; Hydrologic modeling

Analysis and Results

1. Topography of Minsar River Basin
2. Landuse classification using satellite data
3. Analysis of soil characteristics
4. Generation of water table and TDS contours
5. Analysis of lithologs; preparation of fence diagram
6. Hydrological water balance

7. Pump test data analysis
8. Geophysical survey data analysis
9. Isotope analysis of water samples
10. Geochemical and bacterial analysis of water samples
11. Socio-economic survey including coastal belt plantation
12. Numerical simulations

Adopters of the results of the study and their feedback: Study yet to be completed
List of deliverables (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programs, users interaction workshops)

1. Reports
2. Training Programs
3. Research Papers

Major items procured:

Procurement of chemical reagents and plastic ware (since April 2013)

Lab facilities used during the study:

1. Soil and Water Lab, NIH
2. Nuclear Hydrology Lab, NIH
3. Water Quality Lab, NIH
4. Water Quality Lab, GWRDC
5. District Laboratory, PHED, Porbandar

Data procured and/or generated during the study:

1. Hydrogeological database
2. Landuse database
3. Soil database

Study Benefits/Impact:

Measurable indicators	**Achievements**
Generation of database on GIS for Minsar River Basin	Database pertaining to hydrogeology, landuse and soil
Hydrological water balance	Computation of water balance components
Technology transfer	Organization of two training courses in Gujarat (at Anand and Rajkot) till date during the project period

Specific linkages with Institutions and/or end-users/beneficiaries:
Study in collaboration with Gujarat Water Resources Development Corporation (GWRDC), Govt. of Gujarat, Gandhinagar

Future plan:

1. Geochemical and isotope analysis to continue.
2. Numerical simulations
3. Organization of training course on 'Coastal Groundwater Modeling and Management' in March 2014.
4. Submission of Final Report by March 31, 2014.

4. PROJECT REFERENCE CODE: EU-sponsored Project no. 282911

EU-sponsored Project no. 282911 entitled **"Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India".**

i. List of Work Packages

Work Package (WP) number	WP Title	Lead organization
WP 1	Bank Filtration in Urban areas under varying Pollutant loads and flood situation	HTWD, Germany
WP 2	Managed Aquifer Recharge and Soil Aquifer Treatment	KWB, Germany
WP 3	Constructed wetlands and other natural treatment systems for wastewater treatment and reuse..	IIT Bombay
WP 4	Post-treatment of water from natural treatment systems for different applications	IHE, Netherlands
WP 5	Modelling and system design	BRGM, France
WP 6	Integrated sustainability management	CEMDS, Austria
WP 7	Training and Dissemination	NIH
WP 8	Management	FHNW, Switzerland

ii. NIH's involvement

- In Work Packages (WPs) - WP1 , WP2 , WP 5 and WP7.
- NIH is the Lead agency in WP7.

iii. Targeted Areas for R & D works

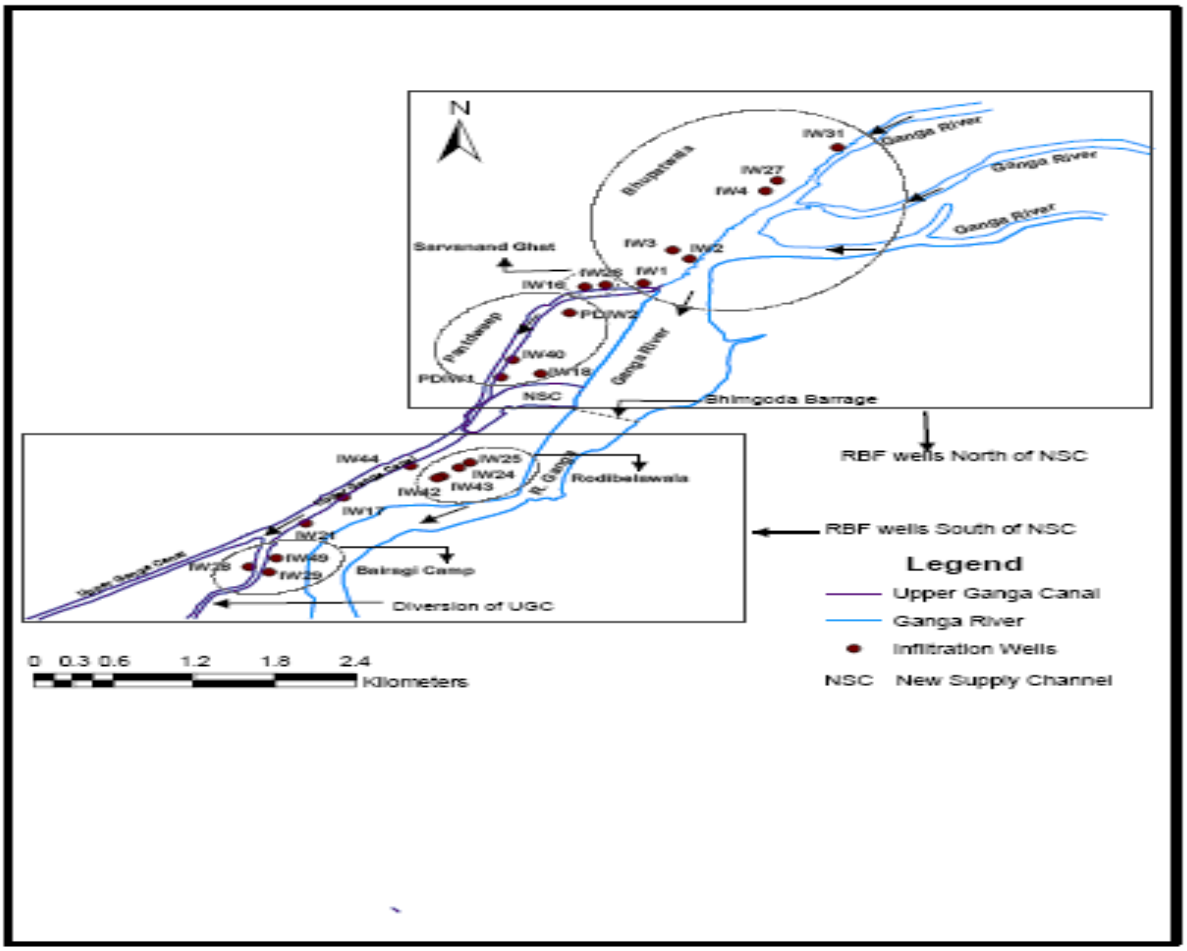
For WP 1 : Haridwar, and Baseline data collection from existing RBF sites in India and modelling.
For WP 2 : Raipur Municipal Area.
For WP 5 : Based on the baseline data to be collected from WP1, & WP2, involvement in modelling of the respective site.

iv. Progress made (Since April, 2013 up to September, 2013)

(a) **Work Package 1 : Bank Filtration in Urban areas under varying Pollutant loads and flood situation**.

For research, training and demonstration (RTD) purposes, NIH has been entrusted with the Haridwar RBF site (see study side map) for periodic data collection, analysis and modelling. In Haridwar site, 22 large diameter (10 m) bottom entry caisson RBF wells of 7-10 m deep, locally called Infiltration wells(IWs), are operating to extract bank filtrate water from the river Ganga and the Upper Ganga Canal (UGC) to meet part of the drinking water supply of the Haridwar city. In general, monthly water samples but during monsoon period bimonthly water samples , from 29 locations which include 22 IWs, 3 locations each from the river Ganga and the UGC, 1 location of groundwater samples (Open well) are being collected

to determine the concentrations of 20 water quality constituents (16 physico-chemical, 2 bacteriological and 2 heavy metals) and isotopic composition. Water quality parameters and isotopic analysis have been carried out during the period April-September, 2013 in the water quality and isotope laboratory, respectively. Groundwater levels and river stages have also been measured simultaneously. Analyzed results are shared with task leaders from time to time for carrying out other tasks of this work package. Using data collected from the field, a 3-D steady-state groundwater flow modelling of Haridwar RBF site by employing visual MODFLOW has been carried out earlier to simulate the RBF flow field. The transient simulation is in progress at the HTWD, Germany. Presently, work is in progress to develop a semi-analytical model for computation of increase of canal recharge due to pumping and the corresponding decrease in river depletion.



Map showing locations of pumping wells along the River Ganga and UGC in Haridwar.

Baseline data collection for the existing RBF wells in other part of the country

During July, 2013 a second round of visit to different potential RBF sites of Bihar, Jharkhand, Andhra Pradesh, and Jammu has been carried out by respective Regional Centre of NIH along with HTWD, Germany and collected water samples from various places and analyzed to develop baseline data for preparing a master plan.

(b) Work Package 2 : Managed Aquifer Recharge and Soil Aquifer Treatment

For RTD activities on WP-2, NIH is involved with Raipur Area site along with NGRI, RMC, and KWB-Germany. In the Raipur area, investigations on two sites (Talibanda Lake area and Talibanda village area) identified for MAR study are in progress.

Work related to water quality sampling campaign and lake bathometric survey has been carried out. Water balance computation of the lake incorporating all hydrological variables is in progress. Water level of the lake is being monitored weekly manual observation.

(c) Work Package 5 : Modelling and System Design

In this work package, NIH has a secondary role, i.e., data being collected from WPs 1,& 2,will be used for the activities of WP5.

As a part of the WP5 deliverable, NIH has taken up the modelling of RBF site in Haridwar. Modelling work aiming at simulation of well fields in response to the river-aquifer interaction, operation of 22 RBF wells under different stress conditions is in progress. The flow modelling is also intended to determine the travel time, flow path and also flow budgeting.

(d) Work Package 7 : Training & Dissemination

In this Work Package, NIH has the lead role supported by 11 other project partners.

The third biannual meeting of the 'Saph Pani' project to review the progress of activities was held at Berlin i during 27 May-01 June, 2013 along with an exposure and practitioner trip. In the meeting, review of progress of each WPs and shortfalls had been discussed along with finalization of work plan for next 6 months. From NIH, 3 scientists and 2 technical staff participated in the Berlin session.

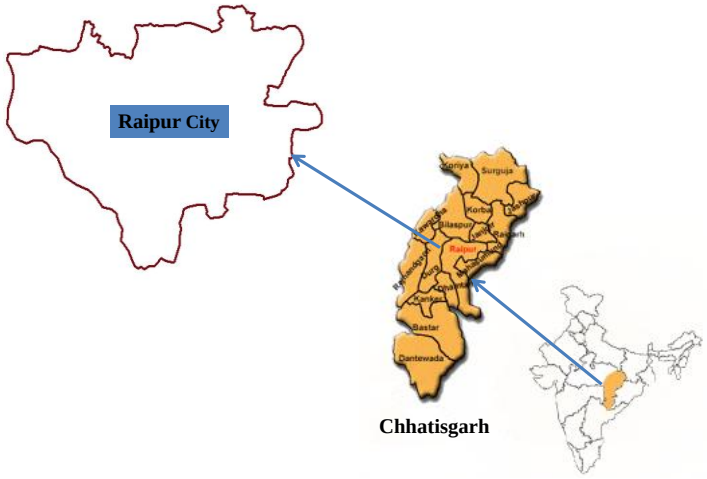
The third and the last training course of its series on "Application of wetlands and other natural systems in India" will be organized by IIT Bombay and NIH at Mumbai during 20-27 November, 2013 along with fourth biannual review meeting.

Time to time, Tele-conferencing and Skype meeting take place with work package partners and Project Coordinator to finalize task, and review progress of activities.

5. PROJECT REFERENCE CODE: NIH/GWD/NIH/11-14

Title of the Study: **Managed Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)**

Location Map Study area is Raipur, the capital city of Chhattisgarh lies between 21° 10'and 21° 21' N latitudes and 81° 32' to 81° 44'E longitudes.



Objectives

1) To identify the potential recharge sites for groundwater (GW) augmentation,
2) To model & analyze aquifer responses due to the recharge from the identified potential recharge sites,
3) To manage the augmented GW resources for subsequent potential uses.

Statement of the problem, End users/beneficiaries of the study:

Raipur city has 154 small and large water bodies. These water bodies are both natural and manmade, locally called "talab". These talabs are connected by storm water channels and hence have specific catchment area. Out of 154 talabs, 85 talabs are in place, remaining talabs have lost their entity because of the development activities. Most of the existing talabs face deteriorating water quality due to disposal of municipal wastes both solid and liquid.

Raipur area also faces problem of depleting groundwater levels due to its excessive withdrawal. To overcome these problem a Managed Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR) scheme has been envisaged as a pilot study with objectives to enhance groundwater recharge from talab through aquifer storage treatment and managing the augmented groundwater resources for subsequent potential uses. To examine potential of MAR in Raipur area, one of the talab catchments namely, Teliabanda is being studied in detail.

Approved action plan

- Literature Review

- Field Investigation & Data Collection
- Determination of Availability of Surface water & Ground water
- Recharge Site Identification
- Estimation of Groundwater Recharge and Simulation of Aquifer response
- Analysing Water Supply & demand Pattern
- Demand Management

Objectives & Achievements

To identify the potential recharge site for groundwater (GW) augmentation	Recharge site (Teliabanda Lake) have been identified
To model & analyze aquifer response due to the recharge from the identified potential recharge site	The elevation- volume relationship is developed and water quality of Lake is analyzed. The water balance of the lake is in progress. The modeling will be started after estimation of recharge.
To manage the augmented GW resources for subsequent potential uses	Will be taken up after completion of second objective.

Analysis and Results

To know the geometry and capacity of lake, a bathymetric survey has been carried out. Based on the survey the depth contour has been plotted and the submerged area corresponding to each contour was calculated. The depth- area and depth -volume curve have been developed to ascertain the capacity of lake. The water level in the lake is being monitored weekly. The water quality parameters of the lake at different location have been analyzed(Refer Table 1) to quantify the pollution level of lake.The water quality parameters includes pH, EC, total dissolved solids (TDS), hardness, calcium, magnesium, sodium, Potassium, alkalinity, bi-carbonate, nitrate, nitrite, sulphate, chloride, DO,BOD, COD, fecal and total coliform. The available geological formation (Bore log data) of the Raipur area is also being analyzed. The water balance of the lake is in progress.

Table 1: Water quality parameters of Teliabanda Lake^{2+}

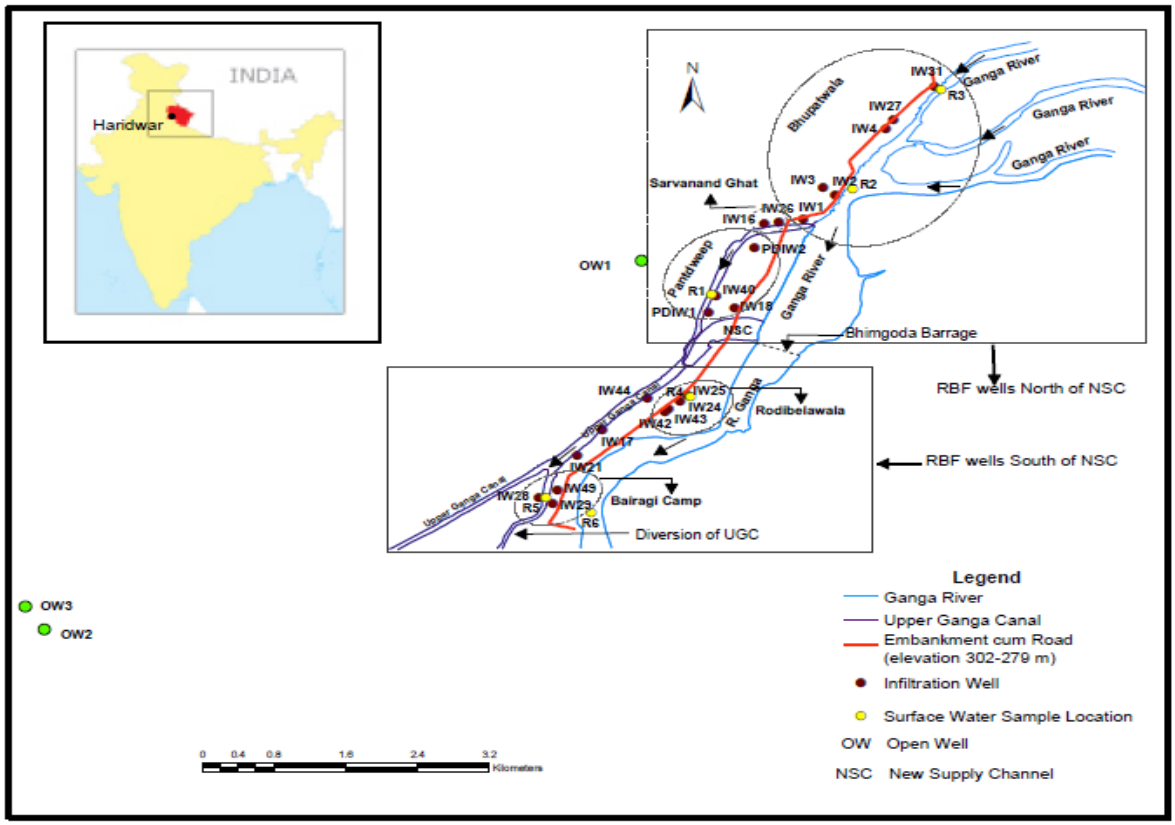
	Teliabanda Lake				
Parameters	Location 1	Location 2	Location 3	Location 4	Location 5
pH	7.9	8.1	8.2	8.2	8.0
EC (µs/cm)	640.0	636.0	633.0	633.0	632.0
Turbidity (NTU)	22.0	28.0	24.0	27.0	24.0
Hardness (mg/l)	120.0	126.0	120.0	118.0	120.0
Ca^{2+}(mg/l)	28.1	29.7	34.5	32.1	32.1
Mg^{2+} (mg/l)	12.2	12.6	8.3	9.2	9.7
Na^{+} (mg/l)	78.9	76.0	78.2	73.6	79.1
K^{+} (mg/l)	26.9	26.6	26.1	25.7	26.4
Fe^{2+} (mg/l)	0.1	0.2	0.2	0.2	0.2
Mn^{2+} (mg/l)	1.0	0.5	0.5	0.5	0.4

$HCO3^-$ (mg/l)	170.0	176.0	172.0	175.0	170.0
Cl^- (mg/l)	93.6	87.6	91.6	89.6	87.6
$PO4^{3-}$ (mg/l)	0.1	0.2	0.1	0.1	0.1
$SO4^{2-}$ (mg/l)	31.0	30.0	30.0	31.0	26.0
$N03^-$ (mg/l)	3.1	3.5	2.2	2.2	1.8
DO (mg/l)	7.0	6.9	7.0	6.5	5.1
BOD (mg/l)	2.6	3.4	2.2	2.6	2.2
COD (mg/l)	31.5	39.3	15.7	15.7	7.9
Fecal Coliform (MPN/100ml)	9.0	4.0	4.0	9.0	9.0
Total coliform (MPN/ 100 ml)	23.0	9.0	23.0	43.0	93.0

6. PROJECT REFERENCE CODE: EU-sponsored Project no. 282911

Title of the study: Flow and Contaminant Transport Modeling of Riverbank Filtration.

Location map



Location of 22 Riverbank filtration wells along the river Ganga and the Upper Ganga Canal system in Haridwar

Study objectives:

(i) To analyze and model the flow paths and travel times of the existing bank filtration sites along the bank of the Ganga River in Haridwar.

(ii) To model and evaluate removal performance of organic pollutants, coliform bacteria and other pathogens by Bank Filtration.

Approved action plan:

- Data collection and base data computerization (6 months)
- Conceptualization of the problem, model setup, model data preparation (6 months)
- Part-I report preparation- Model Calibration, validation and analysis (1 year)
- Contaminant Transport Modeling & analysis etc (9 months)
- Report preparation (3 months)

Action plan for forthcoming one year (2012-2013)

Review Literature	Completed

Reconnaissance Survey of study sites	Completed
Data collection and base data analysis	In progress
Analysis of field data (Conceptualization of the problem, model setup, model data preparation)	In progress
Contaminant Transport Modeling & analysis	Yet to be taken up

Objectives and Achievements:

Objectives	Achievements
• To analyze and model the flow paths and travel times of the existing bank filtration sites along the bank of the Ganga River in Haridwar.	• The baseline data for flow and contaminant transport modeling are going on monthly and bimonthly basis, and assimilation of various other data related to flow modeling is going on simultaneously. • The conceptual framework for the flow model has been prepared. Steady-state modelling of bank filtrate travel-time and flow path has been carried out.
• To model and evaluate removal performance of organic pollutants, coliform bacteria and other pathogens by Bank Filtration.	• Will be followed up after accomplishing the first objective

Results:

Analysis of field data (Conceptualization of the problem, model setup, model data preparation): The Conceptualization of the flow model has been completed.DEM (Digital Elevation Model) for the study area using ASTER data has been generated. Aquifer characterization and hydrogeological evaluation of bank filtration case study site has been completed. Modelling and estimation of bank filtrate travel-time and flow-path is in progress. Water quality analysis for major parameters such as turbidity and pathogens for the samples collected during April, 2013 – September, 2013 has been completed.

List of deliverables: Technical Reports, training programmes, user's interaction workshop and papers.

Other Technical work carried out by the Division during April – September, 2013

1. Scientists of the Division have 05 publications (accepted/published) in national and international journals/conferences/symposia during the period.

2. Scientists have delivered 02 lectures during various training/workshop programmes.

3. Organized one half day joint interactive workshop on 'DSS(P) Applications for Mahi Basin, Gujarat' at State Water Data Centre, Gandhinagar on Aug. 29, 2013.

4. Scientists have guided 03 M.Tech, 06 summer interns' students and also guiding 02 interns students.

5. 02 scientists have attended 02 training course and workshops under DSS(P) of HP-II project.

HYDROLOGICAL INVESTIGATION DIVISION

Scientific Manpower

S N	Name	Designation
1	Sri C P Kumar	Scientist F & Head
2	Dr. Sudhir Kumar	Scientist F
3	Dr. S D Khobragade	Scientist D
4	Dr. S P Rai	Scientist D
5	Dr. M S Rao	Scientist D
6	Sri S K Verma	Scientist D
7	Sri P K Garg	Scientist B
8	Sri Rajeev Gupta	SRA
9	Sri U K Singh	SRA
10	Sri V K Agarwal	SRA
11	Sri Jameel Ahmed	SRA
12	Sri Vishal Gupta	RA

WORK PROGRAM FOR THE YEAR 2013-14

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1	Assessment of Sensitivity of Open Water Evaporation to Increase in Temperature for Different Climatic Regions of India	S. D. Khobragade (PI) C. P. Kumar Manohar Arora A. R. Senthil Kumar	**2 years** (04/12-03/14) **Continuing Study**
2	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**2 years** (07/12-06/14) **Continuing Study**
3	Water Availability Studies for Sukhna Lake, Chandigarh	S. D. Khobragade (PI) C. P. Kumar Sudhir Kumar A. R. Senthil Kumar P. K. Garg V. K. Agarwal	**2 years** (04/13-03/15) **New Study**
4	Isotope Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI) C. K. Jain S. P. Rai S. D. Khobragade P. K. Garg Two Officers from CGWB	**2 years** (07/13-06/15) **New Study**
5	Identifying Wind Patterns and Cloud Condensation in Parts of Himalayas using Isotopes	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**2 years** (10/13-09/15) **New Study**
6	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Parts of Satluj River Basin using Isotopes	S. K. Verma (PI) S. P. Rai (Co-PI) M. S. Rao C. P. Kumar Mohar Singh	**2 years** (10/13-09/15) **New Study**
SPONSORED PROJECTS			
7	National Program on Isotope Fingerprinting of Waters of India (IWIN)	M. S. Rao (PI) Sudhir Kumar S. P. Rai S. K. Verma P. K. Garg Gopal Krishan	**6 years** (07/07–12/13) **Continuing Study**
8	Groundwater Dynamics of Bist-Doab Area, Punjab using Isotopes	M. S. Rao (PI) Sudhir Kumar S. K. Verma P. K. Garg Gopal Krishan CGWB Officials	**5 years 3 months** (10/08-12/13) **Continuing Study**
9	Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka	Sudhir Kumar (PI) J. V. Tyagi S. P. Rai Anupma Sharma B. K. Purandara C. Rangaraj	**5 years 6 months** (10/08-03/14) **Continuing study**

S. No.	Study	Team	Duration/ Status
10	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	M. S. Rao (PI) C. P. Kumar S. P. Rai	**3 years** (09/12-08/15) **Continuing Study**
11	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI) M. S. Rao Surjeet Singh S. K. Verma C. P. Kumar Sudhir Kumar V. K. Agarwal Rajeev Gupta S. L. Srivastava Vishal Gupta Mohar Singh	**3 years** (06/12-05/15) **Continuing Study**
12	Review of Groundwater Resources in the Indo-Gangetic Basin: A Case Study on Resilience of Groundwater in the Punjab to Withdrawal and Environmental Change	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**One year 4 months** (02/13-05/14) **Continuing Study**
13	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar V. K. Agarwal Vishal Gupta Mohar Singh	**3 years** (10/12-09/15) **Continuing Study**
14	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Dr. Sudhir Kumar (PI) Dr. S. P. Rai Dr. C. K. Jain Mr. P. K. Garg	**2 years** (05/13-04/15) **New Study**
CONSULTANCY PROJECTS			
15	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management	S. D. Khobragade (PI) C. P. Kumar R. D. Singh S. P. Rai C. K. Jain V. K. Agarwal	**2 years** (07/11-06/13) **Continuing Study**
16	Pre-dredging and Post-dredging Bathymetric Survey of Ramgarh Tal Lake, Gorakhpur, UP	S. D. Khobragade (PI) C. P. Kumar R. D. Singh V. K. Agarwal	For Pre-dredging Survey 6 months (11/12-04/13) **Continuing Study**

S. No.	Study	Team	Duration/ Status
17	Assessment of Impact of Coal Mining from Mahan Coal Block on Groundwater Recharge and Sedimentation in Rihand Reservoir and to Suggest Appropriate Measures to Mitigate the Identified Impacts	Sudhir Kumar (PI) Sanjay Kumar Jain Jai Vir Tyagi Surjeet Singh S. D. Khobragade R. K. Jaiswal P. K. Garg	**6 months** (04/13-09/13) **New Study**
18	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur	Sudhir Kumar (PI)	**3 years** (05/13-04/16) **New Study**
19	Impact Assessment of Ash Pond on the Groundwater Quality in the Surrounding Villages of NTPC Simhadri through Stable Isotopic Studies	Sudhir Kumar (PI)	**1 year** (07/13-06/14) **New Study**
20	Identification of Source and Locations of Leakage/Seepage from Kaushalya Dam, Haryana	S. P. Rai (PI)	**6 months** (08/13-01/14) **New Study**

1. PROJECT REFERENCE CODE: NIH/HID/INT/2012-14/1

Title of the Study : **Assessment of Sensitivity of Open Water Evaporation to Increase in Temperature for Different Climatic Regions of India**

Study Team : S. D. Khobragade (PI)
C. P. Kumar
Manohar Arora
A. R. Senthil Kumar

Type of Study : Internal

Date of Start : April 2012

Date of Completion : March 2014

Location Map

Udaipur

Chandigarh

Study Objectives

(a) To assess the impact of rising temperature on some temperature dependent factors affecting open water evaporation
(b) To assess the impact of rising temperature on open water evaporation in different climatic regions of India using routinely observed data
(c) To compare the variation in impact on open water evaporation under different climatic settings for different scenarios of temperature rise

Statement of the Problem

A number of studies have been reported in different parts of the world on the assessment of possible impacts of global temperature rise on water resources and hydrologic cycle. However, only a few studies have emphasized the impact primarily on evaporation. Trend analysis of evaporation data shows different trends in different regions, the world over. Although studies using the GCMs are considered as more realistic for global scales, not all the variables required for calculation of more complex evaporation formulae are available

from all climate models. Hydrological models are, hence, claimed to be more useful and suitable for regional and local scales, as they have the ability to incorporate projected variations in climatic variables as well as other hydrological parameters. However, hydrologic models that use simpler form of evaporation and evapotranspiration formulae, generally do not have scope for assessing the impact of temperature on various atmospheric variables which affect evaporation. As far as evaporation is concerned, changes in atmosphere variables caused by temperature changes could have an important effect on overall changes in evaporation. Thus, for the purpose of studying impact of global warming on a more specific component like evaporation, specific evaporation model such as Penman model which uses as many input parameters as the factors affecting the process, could be preferable because, as pointed out by IPCC (2001), '*equations that do not consider explicitly all meteorological controls may give very misleading estimates of change*'. Moreover, use of GCMs and RCMs, as well as other sophisticated hydrological models, requires technical expertise that may not always be available locally. For such situations, there is a need for development of a simple methodology to assess the sensitivity of local evaporation to rising temperature using routinely observed meteorological data.

Action Plan

Activity Schedule (Quarterwise: April 2012 to March 2014)

S. No.	Activities	Quarters							
		1	2	3	4	5	6	7	8
1.0	**PREPARATORY WORK**								
1.1	Selection of study area	√							
1.2	Review of literature	√	√	√	√				
1.3	Identification of data requirement	√							
1.4	Collection and compilation of data	√	√						
2.0	**DATA INTERPRETATION AND ANALYSIS**								
2.1	Impact of temperature rise on various meteorological parameters in different climatic settings			√	√				
2.2	Impact of temperature rise on evaporation in different climatic settings					√	√		
2.3	Comparison of variation in impact of temperature rise on evaporation of different climatic regions						√	√	
3.0	**PROJECT REPORT**								√

Objectives vis-à-vis Achievements

Objectives	Achievements
To assess the impact of rising temperature on temperature dependent factors	Analysis completed for Udaipur and Chandigarh Procurement of data for two more stations (Mumbai and Tehri Garhwal) under

	progress
To assess the impact of rising temperature on open water evaporation in different climatic regions of India	Analysis completed for Udaipur and Chandigarh region
To compare the variation in impact on open water evaporation under different climatic settings	Comparison of results carried out for Udaipur and Chandigarh After procurement of data for other two stations (Mumbai and Tehri Garhwal), the inter-comparison would be extended to all the four stations.

Analysis and Results

Based on the expected change in various temperature dependent parameters, impact on evaporation rates has been studied for Udaipur and Chandigarh. For Udaipur region, daily evaporation rates are expected to rise significantly (upto 30%) during the monsoon and to some extent (upto 8%) during the winter. However, they are expected to fall by about 5% during the summer. As far as Chandigarh region is concerned, while the normal range of evaporation from open water surface at Chandigarh is 3.20 mm (January) to 10.98 mm (May), it is expected to shift to a range of 3.44 mm (December) to 8.98 mm (May). Thus, evaporation is expected to actually decrease during summer months.

Detailed analysis of inter-relationships between the projected changes in various temperature dependent parameters for Udaipur region has been carried out. Results indicate that the changes in evaporation regime would be influenced most by the changes in the regime of vapour pressure deficit (VPD), followed by daily maximum temperature (T_{max}), net outgoing longwave radiation (R_{nl}), saturation vapour pressure (e_s) and net radiation (R_n) in that order. Changes in the regime of other factors, namely, daily minimum temperature (T_{min}) and actual vapour pressure (e_a) would have a lesser influence in determining the projected changes in evaporation. Changes in VPD would be more due to changes in e_s and less by changes in e_a while the changes in e_s themselves would be more dictated by changes in T_{max}. Since e_a has a strong relation with net long-wave radiation (and hence with net radiation also), changes in VPD would also be determined by relative changes in net long-wave radiation. This means that changes in evaporation regimes in the study area would be directly or indirectly controlled by changes in T_{max} and radiation regime which is not surprising for a semi arid region. Since changes in VPD are expected to be upto more than 200% while those of net radiation would be only upto 30%, change in VPD would dominate in the impact on changes in projected evaporation.

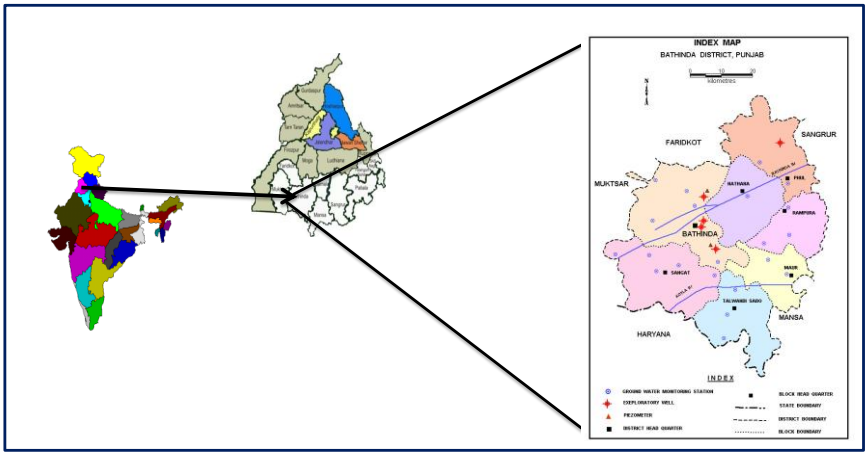
Future Plan

The study is to be carried out for two more study areas of India, namely, Mumbai representing the coastal climate and Tehri Garhwal representing a higher altitude region. It is also proposed to write research papers.

2. PROJECT REFERENCE CODE: NIH/HID/INT/2012-14/2

Title of the Study	:	**Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab**
Study Team	:	M. S. Rao (PI) C. P. Kumar Gopal Krishan
Type of Study	:	Internal
Date of Start	:	July 2012
Date of Completion	:	June 2014

Location Map



Study Objectives

i) To investigate the water quality in multi-aquifer system of Bhatinda and neighbouring area
ii) To map the groundwater age distribution and recharge zones
iii) Evaluation of groundwater quality in accordance with its source of origin and age
iv) To suggest the remedial measures to improve the groundwater conditions

Statement of the Problem

Electrical conductivity (EC) of groundwater in the district ranges from 312 to 5800 µS at 25^0C. Around 60% of the district area falls with EC value exceeding 2000 µS, whereas 20% of the district area falls with EC exceeding 3000 µS at 25^oC. The fluoride (F) values in some areas exceed 6 mg/l. Origin of high salinity and high fluoride in groundwater and its distribution in space is not well understood. In the present study, these aspects will be examined in detail for better prospects of groundwater utilization and future development.

Action Plan

Year	October 2013 to June 2014	Remark
Oct 2013 to June 2014	Groundwater inventory Identifying the sampling sites for isotopic and water quality analysis Data collection Water sampling, analysis and data interpretation Report writing	Report preparation as per table below.

Activity Schedule (Quarter-wise from October 2013 to June 2014)

Activity	1st	2nd	3rd
Sampling (groundwater, surface water, precipitation)	♦		
Collection of data	♦		
Isotopic analysis (δD and $\delta^{18}O$) of samples	♦		
Water quality analysis of surface water and groundwater samples	♦		
Annual report	♦		
Interim report	♦	♦	
Publications and reporting in conferences	♦	♦	♦
Final report		♦	♦

Timeline and justification for time over runs: NA (program is going as per the schedule)

Objectives vis-à-vis Achievements

Objective	Status	Work Done
To investigate the water quality in multi-aquifer system of Bhatinda and neighbouring area	In Progress	Analysis of stable isotopes and water quality of groundwater samples
Evaluation of groundwater quality in accordance with its source of origin and age	In Progress	Maps of water quality parameters are being prepared

Analysis and Results

The groundwater samples were collected from 20 sites during first field visit covering the entire 7 blocks of the Bhatinda district and analysed for EC, stable isotopes and major ions. Electrical conductivity ranged from 470 to 6000 µS/cm at 25^0C. Around 83% of the district area has been found to have EC value more than 1000 µS/cm at 25^oC out of which 30% of

the district area is having EC value more than 3000 µS/cm at 25^{o}C. The southern and western parts show high values of EC. The $\delta^{18}O$ values ranged from -5.85 to -11.26‰ with an average of -8.61‰. The enriched values are found in the eastern and western parts of the district, while southern and northern parts are showing highly depleted values. The chloride values range from 7.3 to 501.6 ppm with an average value of 131.7 ppm. The variation in chloride concentration is similar to variation in EC indicating chloride as a principal component for the observed changes in EC. Increase in chloride content is observed to relate with enrichment in isotopic composition of groundwater indicating evaporation enrichment as one of the major cause for increase in salinity. One of the reasons for observed enrichment could be due to recycling of groundwater. However, confirmation of this aspect requires d-excess (both $\delta^{18}O$ & δD) details. The analysis of δD for estimation of d-excess is in progress.

The fluoride variation is not similar to the variations observed in chloride. Therefore, groundwater chemistry of fluoride appears to be different than that of chloride. The fluoride (F) values range from 0.6 mg/l to 4.4 mg/l and some areas in the district especially in north, central and small patches in south-western and eastern parts show high values of fluoride exceeding the permissible limit of 1.5 mg/l for drinking water standards. The total hardness varies from 151 mg/l to 1468 mg/l and the water belongs to the category of very hard water. The groundwater of the study area is contaminated in terms of nitrate concentration exceeding much above the permissible limits of WHO. The major cause for nitrate pollution is mainly anthropogenic.

Table 1: Statistical Summary of Water Quality Parameters

	Ion Concentration (mg/l)								
	Na^{++}	K^{+}	Mg^{++}	Ca^{++}	F^{-}	Cl^{-}	NO_3^{--}	SO_4^{--}	Hardness
Minimum	4.7	8.2	21.3	17.5	0.6	7.3	2.7	27.1	150.6
Maximum	509.1	199.3	240.9	229.3	4.4	501.6	216.5	784.3	1467.8
Mean	120.2	42.0	81.4	77.6	1.8	131.7	47.4	192.4	541.6
Range	504.4	191.1	219.6	211.8	3.8	494.3	213.8	257.2	391.0
Standard deviation	104.1	45.3	58.3	49.1	1.1	122.7	56.5	179.8	349.0

Study Benefits / Impact

The work will be useful to the state water resource department and academic organizations, district administration etc.

Specific Linkages with Institutions and/or End-Users/Beneficiaries

Department of Geology, Panjab University, Chandigarh

Data Requirement & Expected Source

Hydro-meteorological data will be taken from the state departments.

IPR Potential and Issues: Nil

Major Items of Equipment Needed: None

Publications: 02

Krishan, Gopal, Rao, M. S., Kumar, C. P., Semwal, Prabhat, Tuli, Naresh and Gill, G. S. 2013. Groundwater quality and stable isotopic composition in southwest Punjab. In: Proceedings of International Conference on "Integrated Water, Waste Water & Isotope Hydrology" (IC-WWISH-2013), 25-27 July 2013 at Bangalore University, Bangalore, India. III (VI): 6-10.

Krishan, Gopal, Rao, M. S., Kumar, C. P. and Semwal, Prabhat. Identifying salinization using isotopes and ion chemistry in semi-arid region of Punjab, India. *Journal of Geology and Geosciences* (Communicated).

Future Plan

- An international conference on "Advances in Water Resources Development and Management" (AWRDM-2013) will be organized at Panjab University, Chandigarh during October 23-27, 2013

  Progress as on date:

  - Information brochure released in November, 2012.
  - 102 abstracts are accepted for ORAL presentation.
  - 57 abstracts are accepted for POSTER presentation.
  - Various agencies were contacted for funding the conference.

3. PROJECT REFERENCE CODE: NIH/HID/INT/2013-15/1

Title of the Study : **Water Availability Studies for Sukhna Lake, Chandigarh**

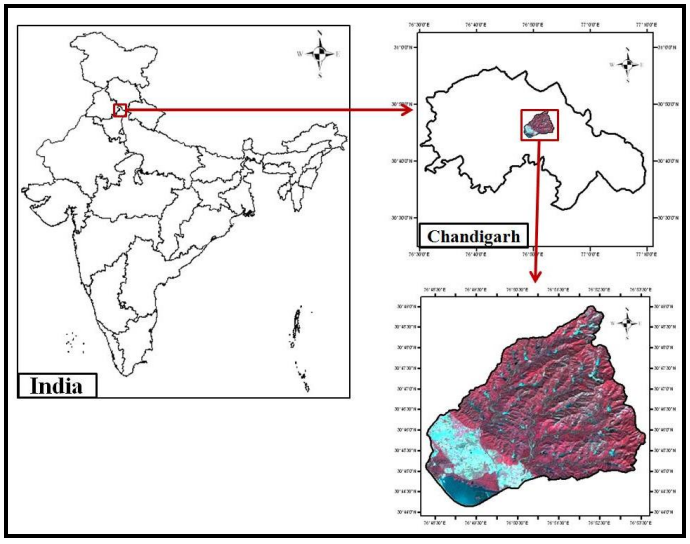
Study Team : S. D. Khobragade (PI)
C. P. Kumar
Sudhir Kumar
A. R. Senthil Kumar
P. K. Garg
V. K. Agarwal

Type of Study : Internal

Date of Start : April 2013

Date of Completion : March 2015

Location Map



Study Objectives

1. To study inflow regime of the lake
2. To study seepage losses from the lake
3. To analyze long term trends in rainfall and evaporation
4. To study the impact of aquatic weeds on lake evaporation
5. To study water availability in the lake

Statement of the Problem

Sukhna lake in Chandigarh is a popular destination for recreation and tourism. However, the lake is in limelight in recent years due to various problems being faced by it. One of the serious problems of the lake is declining water availability in recent years. Water availability analysis has already been carried out based on limited available data, under a consultancy

project for the lake carried out by NIH. Further detailed investigations are required on this aspect. The present study has therefore been proposed as Phase-II of the investigation being carried out on Sukhna lake by the Institute.

Action Plan

Activity Schedule (Quarterwise: April 2013 to March 2015)

Activity	**Quarters**							
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**
Collection of bathymetric map of 2012 from IPRI	*							
Setting of discharge measurement site for the lake	*							
Generation of discharge data		*	*	*	*	*	*	
Field experimental set up for evaporation losses due to aquatic weeds	*							
Collection of rainfall and other hydro-meteorological data	*	*	*	*	*	*	*	
Conducting experiment on evaporation	*	*	*	*	*	*		
Collection of water level data of lake, open wells, piezometer etc.	*	*	*	*	*	*	*	
Samples collection and analysis for stable isotopes	*	*	*	*	*	*		
Samples collection and analysis for Tritium analysis		*			*			
Compilation and processing of data	*	*	*	*	*	*	*	
Preliminary data interpretation			*	*	*			
Trend analysis for rainfall and evaporation			*					
Evaporation estimation and development of pan coefficients						*		
Seepage analysis						*		
Water balance of the lake							*	
Rainfall-runoff relationship analysis							*	
Interim Report					*			
Final Report								*

Objectives vis-à-vis Achievements

Objectives	Achievements
To study inflow regime of the lake	Inflow has been estimated using water balance approach.
To study seepage losses from the lake	Under progress
To analyze long term trends in rainfall and evaporation	Analysis carried out based on trend line
To study the impact of aquatic weeds on lake evaporation	To be considered later
To study water availability in the lake	Water balance has been completed for the year 2012-13. For the monsoon season of 2013, the analysis would be carried out after availability of data.

Analysis and Results

Water balance for the water year 2012-13 has been carried out. It indicates that out of the total 705.5 Ha-m of inflow received by the lake during the water year, 197.1 Ha-m was contributed by the rain directly falling over the lake while the remaining 508.4 Ha-m was contributed by runoff from the catchment. Against 705.5 Ha-m of total inflow volume added to the lake, the total volume of water lost through the lake during the year was 446.4 Ha-m through various processes. This included 253.3 Ha-m of water lost through evaporation, 173.1 Ha-m through seepage and 20 Ha-m through pumping. The total loss of water being lesser than the total inflow, produced a positive balance for the lake causing a net increase of 259.1 Ha-m in the storage volume of lake during the year 2012-13. This resulted in the lake water levels going up by as much as 2 m from the observed water level in the lake from 350.82 m on 1st July, 2012 to 352.82 m msl at the end of June, 2013.

As far as monsoon season of 2012 is concerned, the water balance indicates that out of the 530.29 Ha-m of total inflow received by the lake during the monsoon of 2012, 126.59 Ha-m was contributed by the rain directly falling over the lake while the remaining 403.7 Ha-m was contributed by runoff from the catchment. Of the total 530.29 Ha-m of inflow volume added to the lake during monsoon, 87.88 Ha-m of water was lost through various processes. This included 56.38 Ha-m of water lost through evaporation, 28 Ha-m through seepage and 3.5 Ha-m through pumping. These total losses left a balance of 442.41 Ha-m of change (increase) in volume of the lake. So, the water level of the lake, which was at 350.82 m above msl on 1st July 2012, increased by more than 3 meters to 354.04 m above msl at the end of September, 2012.

4. PROJECT REFERENCE CODE: NIH/HID/INT/2013-15/2

Title of the Study : **Isotope Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains** (New Study)

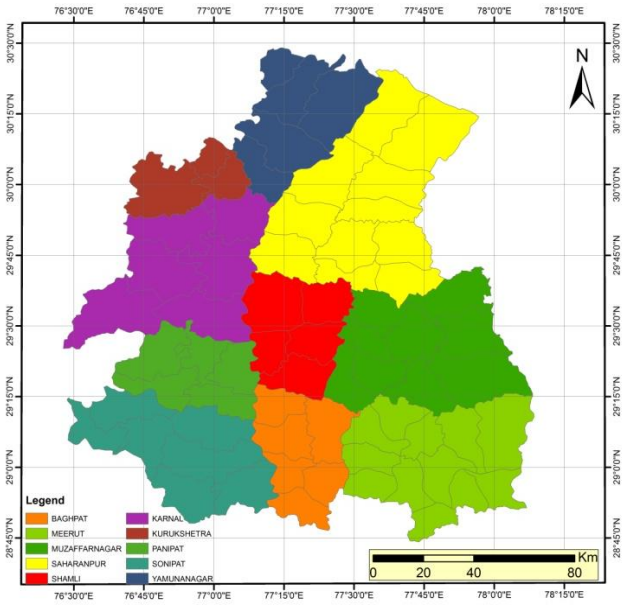
Study Team : Sudhir Kumar (PI)
C. K. Jain
S. P. Rai
S. D. Khobragade
P. K. Garg
Two Officers from CGWB

Type of Study : Internal

Date of Start : July 2013

Date of Completion : June 2015

Location Map



Study Objectives: Objectives of the study are

i. To identify various aquifers present in alluvial tract of the Upper Yamuna Plains
ii. To identify the source of recharge of different aquifers and the interaction between various aquifers
iii. To investigate the continuity of aquifers on both sides of Yamuna river
iv. To determine the groundwater dynamics in different identified aquifers
v. To estimate the groundwater velocity and replenishment potential of the deeper aquifers

Statement of the Problem

Central Ground Water Board, Government of India has started a program for mapping the aquifers in India. This program is designed to make a significant step forward in groundwater resource management by identifying and mapping aquifers, quantifying the available groundwater resources potential and proposing plans appropriate to the scale of demand, aquifer characteristics and the institutional arrangements for management. This work will be systematically implemented in the country, by involving organisations / institutions across India.

Alluvial aquifers are primarily composed of thick unconsolidated Quaternary deposits made up of alternating sequences of sand, silt and clay in various proportions. The major part of water demand in these areas is catered from groundwater which is by and large copiously available because of potential nature of aquifers as well as adequate recharge from rainfall. Western part of the Upper Yamuna Plains has a good irrigation canal network of Western Yamuna Canal, which originates from Hathnikund barrage in Yamunanagar district of Haryana. The unconfined aquifers in the study area are expected to be recharged by seepage from canal network and irrigation return flow apart from rainfall, which is the major source of recharge. The canal water originating at higher altitudes in the Himalayas has different isotopic composition ($\delta^{18}O$ and δD) as compared to the groundwater locally generated in the Upper Yamuna Plains.

Deeper aquifers in the area are supposed to be recharged from the Bhabhar zone, the coarse material deposited as alluvial fans on the margin of Himalayas. Groundwater velocity in the deeper aquifers is expected to be very slow, thus groundwater dating (^{14}C) should give an idea about the groundwater flow direction as well as groundwater velocity in the deeper aquifers. If there is vertical recharge through the semi-confining layers, the same should be easily detected by Tritium dating.

Thus, isotope based investigations can help understanding the surface water and groundwater interactions, aquifer-aquifer interactions, groundwater dynamics and identification of recharge sources and recharge areas of deeper aquifers for taking better management strategies**.**

Action Plan: The action plan is given below.

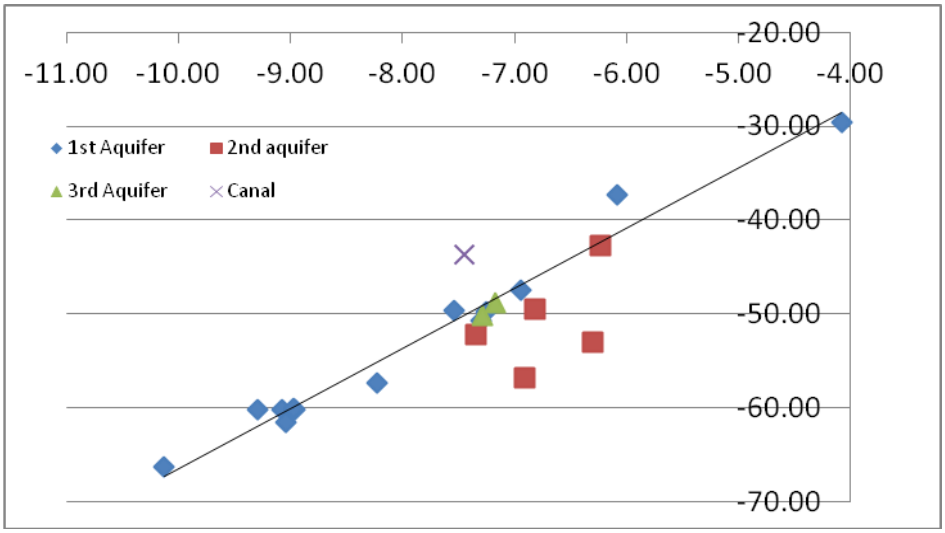
Activity	1st year				2nd Year			
	1st Q	2ndQ	3rd Q	4th Q	5th Q	6th Q	7th Q	8th Q
Collection of available literature and data from CGWB and State Groundwater departments	*							
Identification of wells for groundwater sampling	*							
Construction of aquifer geometry based on available data / information		*						
Collection of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis		*	*		*			
Chemical and stable isotopic analysis of samples		*	*		*	*		
Tritium samples analysis and dating		*	*	*	*	*		
Collection of samples for ^{3}H-He dating					*			
^{3}H-He sample analysis at IAEA					*	*		
Collection of samples for ^{14}C dating		*	*		*			
^{14}C samples analysis at IAEA designated laboratory			*	*	*	*		
Interpretation of data			*	*	*	*	*	

Interim report and discussion of results during the meeting to be hosted by IAEA				*				
Workshop				*			*	
Final draft report and discussion on outcome during the meeting to be hosted by IAEA + final report submission								*

Objectives vis-à-vis Achievements

1. Most of the data available with CGWB has been collected.
2. Wells for groundwater sampling have been identified.
3. First round of sampling has been completed from UP side of the study area.
4. Construction of aquifer geometry based on available data / information is under progress.
5. Analysis of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis is under progress.

Analysis and Results : The results of isotopic analysis obtained so far are shown in Figure below.



Future Plan

1. Collection of samples from rest of the identified locations
2. Analysis of samples for stable isotopes
3. Analysis of physico-chemical parameters
4. Dating of deeper groundwater

5. PROJECT REFERENCE CODE: NIH/HID/INT/2013-15/3

Title of the Study : **Identifying Wind Patterns and Cloud Condensation in Parts of Himalayas using Isotopes** (New Study)

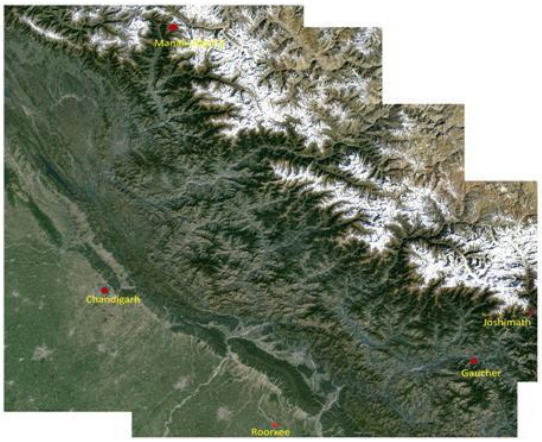
Study Team : M. S. Rao (PI)
C. P. Kumar
Gopal Krishan

Type of Study : Internal

Date of Start : October 2013

Date of Completion : September 2015

Location Map



Study Objectives

1. Spatial and temporal variations in change in specific humidity across Shivalik-Himalayan region
2. Identification of sources of air moisture in different seasons
3. Monitoring the isotopes in air moisture during events of heavy rains and cloud bursts

Statement of the Problem

Atmospheric water vapours play key role in the precipitation events. The isotopic composition of local precipitation is primarily controlled by regional scale processes such as trajectories of the water vapour transport over the continents and the average rainout history of the air masses giving precipitation at a particular place. Stable isotope variation of atmospheric water vapour is controlled by the source of moisture origins, transport trajectory and moisture quantity. The wind transport trajectory is very complex within the Shiwalik-Himalayan region, as found from the results of IWIN study. The observations in IWIN study also demonstrated that increasing flux of monsoon vapour depletes the $\delta^{18}O$ of atmospheric vapour content and enrichment during the withdrawal process. The phase lags between depletion and withdrawal at four stations, two in plains and two in Himalayas, will be closely

monitored to decipher the moisture circulation and the condensation process leading to mild to heavy rains in this region.

Methodology

1. Collection of ground level vapour (GLV) samples using condensation method at all the stations
2. Collection of hydro-meteorological data of all sampling stations
3. Monitoring of isotopes in air moisture - before, during and after the rain event - at Roorkee using recently installed laser based mass spectrometer to investigate the isotopic changes in vapour during moisture condensation process
4. Establishing a relation between direct vapour analysis (using laser based isotope analyser) with condensation based measurements
5. Use of results at 3 & 4 to investigate moisture condensation process in hilly regions from the condensation based sample analysis
6. Results of 2 & 5 will be integrated to attain the objectives of the study.

Action Plan

Year	October 2013 to September 2015	Remark
October 2013 to September 2015	Establishment of the sampling stations at Joshimath (Uttarakhand) and Chandigarh Daily air moisture sampling from Joshimath, Chandigarh, Roorkee, Manali Collection of Hydro-meteorological data Analysis of samples	Report preparation as per table below.

Activity Schedule (October 2013 to September 2015)

Activity	1st (Oct 2013–Mar 2014)	2nd (Apr-Sep 2014)	3rd (Oct 2014-Mar 2015)	4th (Apr-Sep 2015)
Establishing the sampling stations at Joshimath and Chandigarh	♦			
Daily Sampling of air moisture and Analysis	♦	♦	♦	♦
Collection of Hydro-meteorological data	♦	♦	♦	♦
Annual Report/Publications		♦	♦	♦
Final Report				♦

Study Benefits/ Impact

- Identifying the sources of air moisture
- Report on climate change and cloud bursts
- Research publications in high impact journals

Specific linkages with Institutions: Panjab University, Chandigarh; Sai Engineering Foundation, Shimla

6. PROJECT REFERENCE CODE: NIH/HID/INT/2013-15/4

Title of the Study	:	**Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Parts of Satluj River Basin using Isotopes** (New Study)
Study Team	:	S. K. Verma (PI) S. P. Rai (Co-PI) M. S. Rao C. P. Kumar Mohar Singh
Type of Study	:	Internal
Date of Start	:	October 2013
Date of Completion	:	September 2015
Study Area	:	Parts of the Satluj river basin in Punjab State, India

Study Objectives

- To measure radon concentration in water
- To identify the paleo-groundwater in the study area

Statement of the Problem

Radon (^{222}Rn) is a radioactive, colorless, odorless, tasteless noble gas, occurring naturally as the decay product of Uranium. It has a half-life of 3.8 days. Radon gas is considered to be a health hazard due to its radioactivity. It can cause serious diseases like lung cancer if it exceeds certain limit. It has been found that in a country like USA, more than 25,000 deaths occur every year due to high radon concentration in water as well as in air. High concentrations of radon have been observed in certain parts of India also during preliminary studies carried out by various investigators. Therefore, a National Working Group has been constituted by Government of India to study the radon concentration in different materials. NIH has been entrusted to study the radon concentration in waters. Keeping in view the facts mentioned above, this study is proposed to be carried out in parts of Satluj river basin, Punjab to meet out first objective of the study.

Paleo-groundwaters are those groundwaters which are thousands years old. People are drawing groundwater from deeper aquifers without the knowledge of their dynamics. Some of the deeper aquifers may have paleo water which may not serve the needs for water supply for longer time. However, such sources can be used to fulfill some specific needs. Therefore, there is a need to map the paleo-waters to avoid huge investments on other industrial and/or urbanizational developments in such areas. Keeping this in view, the mapping of paleo-groundwater is proposed in the study area where tapping of deeper aquifers has been started at large scale.

Methodology

In order to study the radon contamination in the study area at different locations, different kinds of water samples i.e. river water, lake water, groundwater from shallow as well as deeper aquifers will be collected for in-situ radon measurement. Spatial and temporal variation of radon concentration in different kinds of waters will be studied. The groundwater samples from shallow/deeper aquifers for existing hand pumps, open wells and tube wells will also be collected for tritium and ^{14}C measurement. The hydro-geological data will also be collected for the study area in order to study the hydrogeological features to be linked with the radon concentration in waters and paleo-groundwater.

Action Plan

S. No.	Activity	Oct. 2013 to Sept. 2015							
		1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1.	Review of literature, collection of hydro-geological data/information for the study area etc.	♦	♦						
2.	Preparation of index map of study area, selection of locations/sites for experimental works etc.	♦	♦						
3.	Collection of water samples for radon measurement and tritium analysis, measurement of radon		♦	♦	♦	♦			
4.	Laboratory analysis of groundwater samples for tritium measurement			♦	♦	♦			
5.	Collection of groundwater samples for ^{14}C measurement					♦	♦		
6.	Laboratory analysis of groundwater samples for ^{14}C measurement						♦	♦	
7.	Interpretation of isotopic data						♦	♦	
8.	Preparation of interim report				♦				
9.	Preparation of final report							♦	♦

Data Requirements and Expected Source

- Information of wells located in the study area along with location map (CGWB and/or any other state organization)
- Lithologs of wells (CGWB and/or any other state organization)
- Water level data of the wells (CGWB and/or any other state organization)

List of Deliverables: Papers and reports along with data on radon concentration and paleo-groundwater.

IPR Potential and Issues: Nil

Involvement of End Users/Beneficiaries: The beneficiaries of the study would be water resource planners and managers pertaining to the study area.

Specific Linkages envisaged with Institutions and/or other NGOs: Sharing of data with state groundwater cell, BBMB, State Irrigation Department etc.

Major Items of Equipment Needed: None

7. PROJECT REFERENCE CODE: NIH/HID/DST/2007-13

Title of the Study : **National Program on Isotope Fingerprinting of Waters of India (IWIN)**

Study Team : M. S. Rao (PI)
Sudhir Kumar
S. P. Rai
S. K. Verma
P. K. Garg
Gopal Krishan

Type of Study : Sponsored

Funding Agency : Funded by DST (vide IR/54/ESF/05-2004 dated July 17, 2007)

Budget : 63.34 lakhs

Date of Start : July 2007

Date of Completion : December 2013

Location Map

Samples are collected by NIH from 8 sites (Roorkee, Sagar, Jammu, Kakinada, Tezpur, Kanpur, Manali and Patna) and member organizations collect samples from 85 sites all over India.

NIH-IWIN SAMPLING LOCATIONS MAP

Location	Altitude (m)	Distance from Sea (km)	Starting Date
Roorkee	268	1545	Jul. 2007
Sagar	527	867	Apr. 2008
Jammu	292	1973	Apr. 2010
Kakinada	2	19	May 2010
Tezpur	48	640	May 2011
Kanpur	128	957	Jul. 2011
Manali	3000	1610	Sep.2011
Patna	53	550	Jun. 2012

Study Objectives (NIH+IWIN members)

1. Identifying regional/local water vapour components in the local atmosphere.
2. Residence time and exchange estimate of vapour/water in different hydrological units.
3. Identifying dominant sources of water vapour supply (Arabian sea/ Bay of Bengal/local and long distant continental sources) during different seasons.
4. Isotopic database development.

Statement of the Problem

To identify the source of air moisture during different seasons, isotopic database development and support the IWIN-members in sample analysis.

Action Plan: Final report writing

Timeline and justification for time over runs: NA (program running as per schedule)

Objectives vis-à-vis Achievements

Objective	Status	Work Done
Identifying regional/local water vapour components in the local atmosphere Identifying dominant sources of water vapour supply (Arabian sea/ Bay of Bengal/ local and long distant continental sources) during different seasons	Achieved	Characterized the continental moisture (Arabian sea, Bay of Bengal), regional moisture (Ganga basin), local moisture (at individual locations). Use of soft-computing technique for component mass balancing is in progress and will be completed in time. The interpretation for the local moisture dynamics has been supported with Rose Plots for wind pattern analysis.
Isotopic database development	Achieved	Isotopic database has been developed for approximately 24000 samples =10000 (NIH) + 14000 (PRL)

Analysis and Results

❖ Collected 1000 samples since April, 2013 and sample analysis work is in progress.

❖ *Relationship between Meteorological Parameters and $\delta^{18}O$ of GLV*

The meteorological parameters do not show significant correlation with isotopic composition of $GLV_{CT\&LC}$ (Table 2, 3) due to complex moisture source in this part of India. The GLV_{CT} method is based on sudden freezing of moisture, whereas in GLV_{LC} method, there is development of interface where the relative humidity (RH) and saturation index of air are high, making the interface wetter. Thus, the meteorological parameters are also expected to influence the trapping of moisture (GLV_{LC}) which results in changing isotopic composition. The meteorological parameters on daily scale did not show any correlation with the isotopic composition of GLV, but they show significant correlation with ten daily averaged data. Hence, in the present study for deriving relationship between meteorological parameters and isotopic composition of GLV, we have used ten daily averaged datasets. The saturated vapour pressure is directly proportional to temperature which can be estimated using Magnus approximation. The saturated vapour pressure was determined using the formula given below.

V_{Ps} = {[6.11*Exp (17.625T)]/ (T+243.04)} (Deshpande *et al.*, 2010 and ref. there in)

where, T is temperature in °C at which saturated vapour pressure is to be measured. Temperature (T) and saturated vapour pressure (V_{Ps}) show similar kind of behaviour during

different seasons in both methods. T and V_{Ps} show positive correlation with GLV_{CT} during pre-monsoon and monsoon period and GLV_{LC} during all seasons except monsoon. T and V_{Ps} show significant correlation with GLV_{CT} during post-monsoon only (R^2= 0.58, 0.62 respectively) (Table 3). The GLV_{LC} shows lower correlation with T (R^2= 0.3 to 0.24) during monsoon, post monsoon and winter (Table 2). The GLV_{CT} method show better correlation with RH and S_{ia} than GLV_{LC}. The R^2 value of GLV_{LC} is better than that of GLV_{CT} during monsoon due to prevalence of high diffusive fractionation. The significant correlation of S_{ia} and RH indicates that these parameters play a significant role in the isotopic composition of GLV during the monsoon period.

The meteorological parameters absolute humidity (AH), specific humidity (SH), absolute vapour pressure (V_p) and dew point (D_p) show inverse correlation during all seasons in GLV_{LC} and monsoon period in GLV_{CT} method (Table 2, 3). The liquid condensation methods show inverse correlation with all the meteorological parameters. The meteorological parameters show inverse correlation during monsoon with $GLV_{CT\&LC}$ and significant R^2 values exhibiting the high influence of external moisture source. Significant correlation of meteorological parameters with $GLV_{CT\&LC}$ during post monsoon is due to influence of local vapour. The significant correlation of meteorological parameters with GLV_{LC} than that of GLV_{CT} during pre-monsoon and winter period indicates the influence of similar moisture source (both local and westerlies).

The effect of rain drop re-evaporation also affects the isotopic composition of GLV. Hence to understand the effect of re-evaporation, isotopic composition of the precipitation was correlated with GLV. The precipitation in the study area occurs mainly during monsoon period and few rain events occur during winter and pre-monsoon periods. The isotopic composition of GLV_{CT} shows significant correlation (R^2= 0.4) with isotopic composition of precipitation in monsoon period. Whereas, GLV_{LC} method shows significant correlation with isotopic composition of precipitation (R^2= 0.7) indicating little re-evaporation effect of rain drop. This is due to super saturated condition of moisture source i.e. SWM moisture during the monsoon period. Moreover, due to super saturated nature of atmosphere, the evaporation of rain drops also becomes negligible. During this period the variation in the isotopic composition depends mainly on RH. The lower R^2 value (0.04 and 0.2) of $GLV_{CT\&LC}$ with precipitation during pre-monsoon period clearly shows that raindrops during these seasons experience significant re-evaporation effect. In case of winter period, the correlation between precipitation and $GLV_{CT\&LC}$ is significant (R^2= 0.4) indicating lesser evaporation effect.

The d-excess of $GLV_{CT\&LC}$ (Table 2, 3) are compared with meteorological parameters for understanding the effect of seasonal changes in a much better way. A significant correlation of $GLV_{CT\&LC}$ with meteorological parameters was observed during post-monsoon period only which is due to local/ evaporated continental moisture source received in the study area. The CT method does not show any significant correlation with meteorological parameters during other seasons (Table 3). The lower correlation of GLV_{CT} during pre-monsoon and monsoon periods is mainly due to complex moisture source (local and external).

On the other hand, GLV_{LC} method shows significant correlation with meteorological parameters in all the seasons. A significant correlation between GLV_{LC} and AH, SH, VP and Dp are observed in all the seasons (Table 2). As this method is chiefly affected by the diffusive fractionation, which depends on T, RH and S_{ia}, a significant correlation is observed between GLV_{LC} and RH, S_{ia} during monsoon period only. The T, RH and S_{ia} are lower/ vary

in other periods and cause less diffusive fractionation effect resulting in poor correlation of GLV_{LC} with these parameters.

Overall, the study exhibits the magnification of correlation of meteorological parameters with isotopic composition of GLV by liquid condensation method in comparison to that of cryogenic trap. This enables the understanding the influence of isotopic composition of water vapour in a seasonal scale.

Table 2: Meteorological Parameters (MP) vs Ground Level Vapour in Liquid Condensation Method (GLV_{LC})

{10 daily weighted average}

Parameter	Pre- Monsoon	Monsoon	Post Monsoon	Winter
		$\delta^{18}O$		
Temperature	$\delta^{18}O$= (-0.2xT)- 6.49; R^2= 0.09	$\delta^{18}O$= (0.14xT)- 62.71; R^2= 0.30	$\delta^{18}O$= (-0.63xT)- 3.21; R^2= 0.23	$\delta^{18}O$= (-0.29xT)- 7.97; R^2= 0.20
Relative Humidity	$\delta^{18}O$= (-0.03xRH)- 10.12; R^2= 0.03	$\delta^{18}O$= (-0.391xRH)+ 8.76; R^2= 0.51	$\delta^{18}O$= (-0.31xRH)+ 8.17; R^2= 0.30	$\delta^{18}O$= (0.09xRH)- 20.2; R^2= 0.06
Absolute Humidity	$\delta^{18}O$= (-0.75xAH)- 1.14; R^2= 0.41	$\delta^{18}O$= (-0.77xAH)- 5.94; R^2= 0.24	$\delta^{18}O$= (-1.53xAH)+ 5.28; R^2= 0.70	$\delta^{18}O$= (-0.03xAH)- 5.12; R^2= 0.24
Specific Humidity	$\delta^{18}O$= (-0.66x SH)- 1.36; R^2= 0.41	$\delta^{18}O$= (-0.65x SH)- 7.07; R^2= 0.22	$\delta^{18}O$= (-1.32xSH)- 3.84; R^2= 0.68	$\delta^{18}O$= (-0.55xSH)- 5.63; R^2= 0.24
Vapour Pressure	$\delta^{18}O$= (-5.25xV_p)- 1.36; R^2= 0.41	$\delta^{18}O$= (-5.17xV_p)- 7.07; R^2= 0.22	$\delta^{18}O$= (-10.49xV_p)+ 3.84; R^2= 0.68	$\delta^{18}O$= (-4.38xV_p)- 5.63; R^2= 0.24
Saturated Vapour Pressure	$\delta^{18}O$= (-0.93xV_{ps})- 8.43; R^2= 0.08	$\delta^{18}O$= (5.98xV_{ps})- 46.90; R^2= 0.31	$\delta^{18}O$= (-4.40xV_{ps})- 5.47; R^2= 0.24	$\delta^{18}O$= (-2.73xV_{ps})- 7.53; R^2= 0.20
Dew Point	$\delta^{18}O$= (-0.69xD_p)- 0.01; R^2= 0.41	$\delta^{18}O$= (-0.92xD_p)- 0.64; R^2= 0.26	$\delta^{18}O$= (-1.22xD_p)+ 4.07; R^2= 0.66	$\delta^{18}O$= (-0.42xD_p)- 6.75; R^2= 0.25
Saturation Index of Air	$\delta^{18}O$= (-3.40xS_{ia})- 10.12; R^2= 0.03	$\delta^{18}O$= (-39.14xS_{ia})+ 8.76; R^2= 0.57	$\delta^{18}O$= (-31.03xS_{ia})+ 8.17; R^2= 0.68	$\delta^{18}O$= (9.07xS_{ia})- 20.20; R^2= 0.06
		d- excess		
Temperature	d= (0.73xT)+ 50.56; R^2= 0.07	d= (0.37xT)+ 79.55; R^2= 0.02	d= (3.25xT)- 0.40; R^2= 0.44	d= (0.95xT)+ 45.63; R^2= 0.13
Relative Humidity	d= (0.15xRH)+ 62.06; R^2= 0.03	d= (0.51xRH)+ 48.68; R^2= 0.53	d= (0.49xT)+ 28.17; R^2= 0.05	d= (-0.47xRH)+ 101.57; R^2= 0.10
Absolute Humidity	d= (3.11xAH)+ 25.16; R^2= 0.47	d= (1.58xAH)+ 54.47; R^2= 0.54	d= (5.84xAH)- 15.74; R^2= 0.73	d= (0.2.04xAH)+ 36.70; R^2= 0.16
Specific Humidity	d= (2.76x SH)+ 26.23; R^2= 0.47	d= (1.37x SH)+ 56.11; R^2= 0.51	d= (5.12xSH)- 11.10; R^2= 0.73	d= (1.81xSH)+ 38.08; R^2= 0.16
Vapour Pressure	d= (21.88xV_p)+ 26.23; R^2= 0.47	d= (10.84xV_p)+ 56.12; R^2= 0.51	d= (40.6xV_p)- 11.10; R^2= 0.73	d= (14.39xV_p)+ 38.08; R^2= 0.16
Saturated Vapour Pressure	d= (3.28xV_{ps})+ 58.20; R^2= 0.06	d= (0.82xV_{ps})+ 86.73; R^2= --	d= (22.56xV_{ps})+ 11.37; R^2= 0.45	d= (9.88xV_{ps})+ 42.83; R^2= 0.16
Dew Point	d= (2.80xD_p)+ 22.02; R^2= 0.44	d= (1.89xD_p)+ 43.40; R^2= 0.56	d= (4.76xD_p)- 12.70; R^2= 0.72	d= (1.24xD_p)+ 43.67; R^2= 0.13
Saturation Index of Air	d= (15.38xS_{ia})+ 62.06; R^2= 0.03	d= (50.57xS_{ia})+ 48.68; R^2= 0.53	d= (48.72xS_{ia})+ 28.2; R^2= 0.05	d= (-47.28xS_{ia})+ 101.57; R^2= 0.10

Table 3. Meteorological Parameters (MP) vs Ground Level Vapour in Cryogenic Trap Method (GLV_{CT})

{10 daily weighted average}

Parameter	Pre- Monsoon	Monsoon	Post Monsoon	Winter
		$\delta^{18}O$		
Temperature	$\delta^{18}O$= (-0.20xT)- 4.53; R^2= 0.15	$\delta^{18}O$= (-0.43xT)- 2.08; R^2= 0.03	$\delta^{18}O$= (0.13xT)- 16.83; R^2= 0.58	$\delta^{18}O$= (0.08xT)- 12.93; R^2= 0.02
Relative Humidity	$\delta^{18}O$= (0.07xRH)- 14.14; R^2= 0.24	$\delta^{18}O$= (-0.41xRH)+ 19.47; R^2= 0.50	$\delta^{18}O$= (-0.07xT)- 8.47; R^2= 0.74	$\delta^{18}O$= (-0.08xRH)- 4.42; R^2= 0.06

Absolute Humidity	$\delta^{18}O$= (0.259xAH)- 14.20; R^2= 0.10	$\delta^{18}O$= (-1.01xAH)+ 8.12; R^2= 0.39	$\delta^{18}O$= (0.24xAH)- 17.66; R^2= 0.44	$\delta^{18}O$= (0.11xAH)- 13.02; R^2= 0.01
Specific Humidity	$\delta^{18}O$= (0.21x SH)- 13.59; R^2= 0.08	$\delta^{18}O$= (-0.87x SH)+ 7.15; R^2= 0.37	$\delta^{18}O$= (0.21xSH)- 17.4; R^2= 0.46	$\delta^{18}O$= (0.10xSH)- 12.97; R^2= 0.01
Vapour Pressure	$\delta^{18}O$= (1.63xV_p)- 13.59; R^2= 0.08	$\delta^{18}O$= (-6.94xV_p)+ 7.15; R^2= 0.37	$\delta^{18}O$= (1.65xV_p)- 17.4; R^2= 0.46	$\delta^{18}O$= (0.81xV_p)- 12.97; R^2= 0.01
Saturated Vapour Pressure	$\delta^{18}O$= (-1.08xV_{ps})- 6.08; R^2= 0.18	$\delta^{18}O$= (-1.71xV_{ps})- 7.56; R^2= 0.02	$\delta^{18}O$= (0.90xV_{ps})- 16.3; R^2= 0.62	$\delta^{18}O$= (0.74xV_{ps})- 13.02; R^2= 0.02
Dew Point	$\delta^{18}O$= (0.20xD_p)- 13.78; R^2= 0.07	$\delta^{18}O$= (-1.15xD_p)+ 13.77; R^2= 0.38	$\delta^{18}O$= (0.20xD_p)- 17.64; R^2= 0.44	$\delta^{18}O$= (0.07xD_p)- 12.67; R^2= 0.01
Saturation Index of Air	$\delta^{18}O$= (6.96xS_{ia})- 14.14; R^2= 0.24	$\delta^{18}O$= (-41.1xS_{ia})+ 7.15; R^2= 0.37	$\delta^{18}O$= (-6.87xS_{ia})- 8.47; R^2= 0.74	$\delta^{18}O$= (-8.25xS_{ia})- 12.97; R^2= 0.01
		d- excess		
Temperature	d= (0.35xT)+ 14.19; R^2= 0.26	d= (0.08xT)+ 14.94; R^2= 0.01	d= (0.27xT)+ 13.68; R^2= 0.49	d= (-0.08xT)+ 25.45; R^2= 0.01
Relative Humidity	d= (-0.07xRH)+ 28.02; R^2= 0.15	d= (-0.05xRH)+ 21.55; R^2= 0.10	d= (-0.12xRH)+ 29.39; R^2= 0.49	d= (0.11xRH)+ 13.93; R^2= 0.04
Absolute Humidity	d= (0.06xAH)+ 23.10; R^2= 0.003	d= (-0.08xAH)+ 18.87; R^2= 0.03	d= (0.55xAH)+ 11.06; R^2= 0.47	d= (-0.03xAH)+ 24.53; R^2= --
Specific Humidity	d= (0.08x SH)+ 22.59; R^2= 0.01	d= (-0.06x SH)+ 18.75; R^2= 0.02	d= (0.47xSH)+ 11.78; R^2= 0.47	d= (-0.02xSH)+ 24.52; R^2= --
Vapour Pressure	d= (0.67xV_p)+ 22.59; R^2= 0.01	d= (-0.50xV_p)+ 18.75; R^2= 0.02	d= (3.70xV_p)+ 11.78; R^2= 0.47	d= (-0.19xV_p)+ 24.52; R^2= --
Saturated Vapour Pressure	d= (1.7xV_{ps})+ 17.45; R^2= 0.27	d= (0.36xV_{ps})+ 15.87; R^2= 0.01	d= (1.78xV_{ps})+ 14.85; R^2= 0.49	d= (-0.48xV_{ps})+ 25.04; R^2= --
Dew Point	d= (0.06xD_p)+ 22.92; R^2= 0.004	d= (-0.07xD_p)+ 18.85; R^2= 0.02	d= (0.46xD_p)+ 11.21; R^2= 0.46	d= (-0.06xD_p)+ 24.96; R^2= --
Saturation Index of Air	d= (-7.20xS_{ia})+ 28.02; R^2= 0.15	d= (-5.33xS_{ia})+ 21.55; R^2= 0.10	d= (-12.34xS_{ia})+ 29.39; R^2= 0.49	d= (11.55xS_{ia})+ 13.93; R^2= 0.04

Adopters of the results of the study and their feedback

The IWIN project is a national level program in which various academic institutions and national level organizations are participating. A network of stations has been developed and results of the study are commonly being shared. The program is also generating papers in high impact journals through which the knowledge will be transpired to various other institutions nationally and globally.

List of Deliverables

Total Publications (2007-13) = 22
(Journals-**7;** Conferences**:** International-**9;** National-**5;** Book Chapter-**1)**

Publications (April 2012 to September 2013) = 4
(Journals-**2;** Conferences-**2)**

Rao, M. S., Krishan, Gopal, Kumar, C. P., Tripathi, Shivam and Kumar, Bhishm. 2013. A Pre-feasibility study of isotopes for investigation of monsoon dynamics. NDC-WWC Journal. 2 (1): 5-9.

Krishan, Gopal, Rao, M. S., Jaiswal, R. K., Kumar, Bhishm and Kumar, C. P. 2013. Southwest (SW) monsoon dynamics study in Indo-Gangetic plains using isotopic techniques. Journal of Geology and Geosciences. 2:2 http://dx.doi.org/10.4172/jgg.1000119

Krishan, Gopal, Lohani, A. K., Rao, M. S., Kumar, C. P., Kumar, Bhishm, Rao, Y. R. S, Jaiswal, R. K., Thayyen, J. Renoj and Tripathi, Shivam. 2013. Geospatial correlation of isotopes in air moisture along the southwest monsoon transect in the Indian Sub-continent. In:

Proceedings of International Conference on "Integrated Water, Waste Water & Isotope Hydrology" (IC-WWISH-2013), 25-27 July 2013 at Bangalore University, Bangalore, India. III (VI): 60-64.

Krishan, Gopal, Rao, M. S., Kumar, C. P. and Kumar, Bhishm. 2013. Comparison of isotopic composition of atmospheric moisture within and outside Himalaya - An implication in studying monsoon dynamics. In: Proceedings of International conference "India Water Week 2013 - Efficient Water Management: Challenges and Opportunities" (IWW-2013), 08-12 April 2013 at New Delhi, India. pp. 271-272.

Trainings: 30 technical persons have been trained at various stages of the project.

Major items of equipment procured: Nil

Lab facilities used during the study: Hydrological Investigations division

Data generated during the study: Isotope database for stations at Roorkee, Sagar, Jammu, Kakinada, Kanpur, Tezpur, Manali and Patna

Study Benefits / Impact

The results of the project may be used in developing a new way to understand Indian meteorology and climate change through isotopes in ground level vapour. The temperature dependant isotopic behavior in the condensation process may provide new insight in basic physics, which were not observed or reported earlier.

Specific linkages with Institutions and/or end-users/beneficiaries

Participating Organizations – Anna University, BARC, CGWB, CPCB, CWC, CWRDM, IMD, IIT-Kharagpur, NGRI, NIO, NRL- IARI, PRL

Shortcomings/difficulties, if any: Nil

The results and outcome of the project were discussed before PRC in the final meeting that was conducted on 25th July, 2013 at PRL, Ahmedabad. The PRC and DST committee expressed satisfaction with the outcome of the project and suggested for initiation of IWIN Phase-II and proposed that NIH may take lead for Phase-II program with the support of PRL, Ahmedabad.

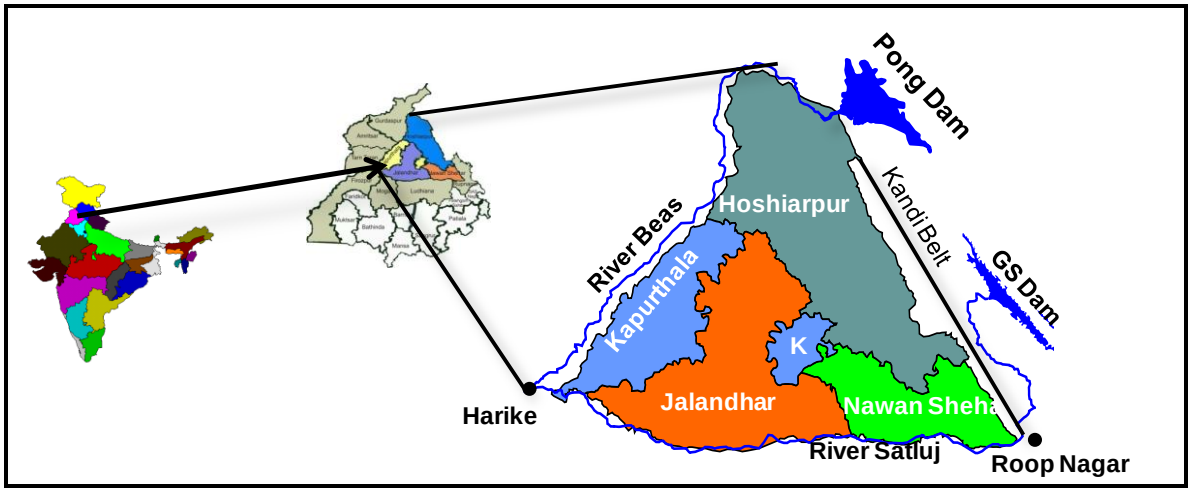
Future Plan **:** Final Report Writing

8. PROJECT REFERENCE CODE: NIH/HID/HP-II/2008-13

Title of the Study	:	**Groundwater Dynamics of Bist-Doab Area, Punjab using Isotopes**
Study Team	:	M. S. Rao (PI) Sudhir Kumar S. K. Verma P. K. Garg Gopal Krishan CGWB Officials
Type of Study	:	Purpose Driven Study (HP-II)
Funding Agency	:	World Bank
Budget	:	121.79 lakhs
Date of Start	:	October 2008
Date of Completion	:	December 2013

Location Map

The Bist Doab is a triangular region and covers an area of 9060 km^2. The area lies between 30^{0}51' and 30^{0}04' N latitude and 74^{0}57' and 76^{0}40' E longitude. It comprises the districts of Hoshiarpur, Kapurthala, Jalandhar and Nawanshahar and parts of the district of Roop Nagar of Punjab State, India. It is bounded by Shiwaliks in the north-east, river Beas in the north east-south west and river Satluj in south east-south west. The area is drained by the perennial rivers Satluj and Beas and their tributaries. They coalesce at the Harike. The climate of the area is influenced by the Himalayas in the north.



Study Objectives

Identifying groundwater recharge zone and recharge sources using groundwater dating and stable isotope techniques; groundwater modeling.

Statement of the Problem

The Bist-Doab region, the region between river Satluj and river Beas, experiences high amount of groundwater depletion due to increased agricultural activities. Hence, it is imperative to identify the recharge zones and recharge sources of groundwater.

Action Plan

Activity	2013
Month/Quarter →	4th
Sample collection of groundwater, surface water, precipitation	✓
Surface water and groundwater data processing	✓
Identification of recharge zones and recharge sources	✓
Integration of water quality, stable and radioactive isotope data and field data along with modelling to develop a general scenario for groundwater flow in aquifers	✓
Publications and reporting in conferences	✓
Preparation of final report	✓

Objectives vis-à-vis Achievements

Objective	Status	Work Done
Identifying groundwater recharge zone and recharge sources using groundwater dating and stable isotope technique; and groundwater modelling	Recharge sources and zones for shallow and deep groundwater have been refined.	*Stable Isotopes & Environmental Tritium:* 716 samples (SW, GW and rain) have been collected from October 2012 to March 2013 making a total of 4477 samples (4477 for stable isotope and 170 for environmental tritium) collected during the entire study period. *Status of Sample Analysis:* Analysed 457 samples for stable isotopes and 28 samples for environmental tritium since last working group meeting. *Water Chemistry:* The groundwater samples collected during pre and post monsoon periods of 2011 have been analysed for water quality using Ion Chromatograph and interpretation of data has been carried out (these results will be presented in the working group meeting). The analysis of groundwater samples collected (116) during January 2013 for water chemistry is in progress.
	In progress	Analyses of water samples for stable isotopes, environmental tritium, carbon dating and water quality.

Analysis and Results

In the last 6 months, major lacunae of development of deep piezometers was completed. Six number of deep piezometers to tap 3rd aquifer were constructed at Saroya, Bhogpur, Tanda, Kapurthala, Sultanpur Lodhi and Nakodar. On completion of drilling, all the wells were scanned for e-logging to identify the aquifer details. On the basis of e-logging, screens were installed. The automatic water level recorders were also installed in these newly constructed piezometers. The recorded water level is planned to collect in the month of October (end of monsoon).

The samples remained for the analysis of environmental tritium, major ions and stable isotopes ($\delta^{18}O$ and δD) will be completed by the mid of November and final report will be submitted by December, 2013.

Publications: 02

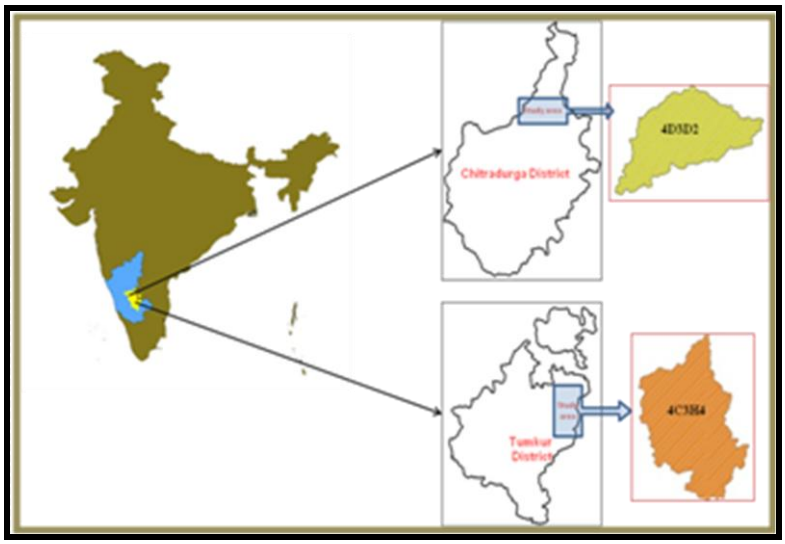
Krishan, Gopal, Lohani, A. K., Rao, M. S. and Kumar, C. P. 2013. Optimization of groundwater monitoring network in Bist-doab, Punjab. In: Proceedings of International Conference "India Water Week 2013 - Efficient Water Management: Challenges and Opportunities" (IWW-2013), 08-12 April 2013 at New Delhi, India. pp. 274.

Purushotaman, P., Rao, M. S., Rawat, Y. S., Krishan, Gopal**,** and Kumar, C. P. 2013. A study on surface water and groundwater interactions in Bist-doab region, India. In: Proceedings of International Conference on "Integrated Water, Waste Water & Isotope Hydrology", 25-27 July 2013 at Bangalore University, Bangalore, India. III (VI): 1-5.

9. PROJECT REFERENCE CODE: NIH/HID/HP-II/2008-14

Title of the Study	:	**Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka**
Study Team	:	Sudhir Kumar (PI) J. V. Tyagi S. P. Rai Anupma Sharma B. K. Purandara C. Rangaraj
Type of Study	:	Purpose Driven Study (HP-II)
Funding Agency	:	World Bank
Budget	:	79.6 Lacs
Date of Start	:	October 2008
Date of Completion	:	March 2014

Location Map



Study Objectives

i) To analyze groundwater productivity at specific study sites including artificial recharge structures and an assessment of potential increases and their contribution to rural livelihood improvement
ii) To develop integrated understanding of hydrologic, social, economic, and institutional perspectives
iii) To improve stakeholder engagement and community participation for developing a common vision, goal and partnership for managing basin's groundwater resources
iv) To identify anthropogenic interventions and evaluate their likely impact for effective groundwater management

v) To arrive at a model for management and regulation of identified over-exploited blocks on an operational basis

Statement of the Problem

Today groundwater resources are exploited as a common pool resource in an open access framework by one and all. This has resulted in over-exploitation of groundwater resources leading to falling groundwater levels and deterioration of groundwater quality. There is an urgent need for formulations of guidelines for management of groundwater, particularly in hard rock areas, where water table is declining rapidly.

Action Plan

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Selection of watersheds	♦	♦										
Reconnaissance surveys		♦	♦									
Data collection (historical)		♦	♦									
Problem conceptualization			♦	♦								
Meetings with participating agencies	♦	♦										
Appointment of project staff	♦	♦	♦									
Procurement of equipment	♦	♦	♦	♦								
Socio-Economic analysis									♦	♦		
Installation of equipment					♦	♦						
Procurement of software				♦	♦	♦						
Database development			♦	♦	♦	♦	♦	♦	♦			
Field interventions to promote artificial recharge								♦	♦	♦	♦	
Development of conceptual model									♦			
Development of groundwater utilization guidelines										♦	♦	
Capacity building and training programs								♦	♦			♦
Report writing											♦	♦

Objectives vis-à-vis Achievements

Objectives	Achievements
To analyze groundwater productivity at specific study sites including artificial recharge structures and an assessment of potential increases and their contribution to rural livelihood improvement	Work in progress
To develop integrated understanding of hydrologic, social, economic, and institutional perspectives	Work in progress
To improve stakeholder engagement and community	Work in progress

participation for developing a common vision, goal and partnership for managing basin's groundwater resources	
To identify anthropogenic interventions and evaluate their likely impact for effective groundwater management	Work in progress
To arrive at a model for management and regulation of identified over-exploited blocks on an operational basis	Work in progress

Analysis and Results

- Hydro-meteorological instruments (evaporation pan, soil moisture sensors and raingauge) and automatic groundwater level recorders were installed in the field. Evaporation rates vary from 2 mm to 8 mm per day in these watersheds. Rainfall is very erratic, both in space and time.
- GIS database has been prepared for both the watersheds including base map, drainage map, road map and water storage structures maps etc.
- Infiltration tests have been conducted at 16 locations in both the watersheds. Low infiltration rates observed in the bottom of tanks indicate chocking of tank beds. Experiment in one rejuvenated tank is under progress.
- Water level data (depth to water level and reduced water level) and rainfall data have been collected for 14 observation wells in Chitradurga watershed (till 2011) and 15 in Tumkur watershed (upto 2011) and contours prepared. Water table fluctuates with the amount of rainfall.
- About 60 groundwater samples from Chitradurga and Tumkur watershed have been collected and analysed for stable isotopes of hydrogen and oxygen. The results indicate that irrigation tanks are not much recharging the groundwater.
- Resistivity survey has been conducted at 18 sites in both the watersheds. The results indicate availability of water in thin bands.
- Pump tests have been conducted at 4 locations. The results indicate low hydraulic conductivity.
- Socio-economic survey has also been conducted. The results are being analysed. More people are to be surveyed to reach at some conclusion.
- A training course on "Hydrological Investigations and Water Management in Hard Rock areas" was organised in Bangalore during 18-22 March 2013.

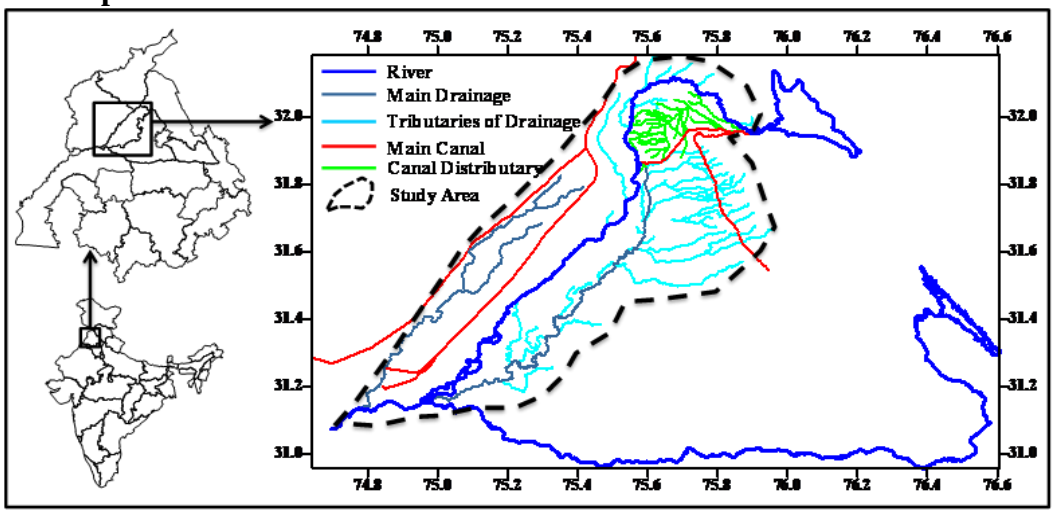
Future Plan

1. Interpretation of data collected so far
2. Report writing

10. PROJECT REFERENCE CODE: NIH/HID/IAEA-1/2012-13

Title of the Study	:	**The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India**
Study Team	:	M. S. Rao (PI) C. P. Kumar S. P. Rai
Type of Study	:	Sponsored
Funding Agency	:	IAEA, Vienna
Budget	:	Euros 1500
Date of Start	:	September 2012
Date of Completion	:	August 2015

Location Map



Study Objectives

1. Assessment of depleting groundwater conditions in north-eastern parts of Punjab.
2. Identifying the regions where groundwater use has caused changes in chemical, stable isotopic composition and age of groundwater.
3. Identifying the areas where deep aquifers are getting modern recharge through their shallow aquifers.
4. Groundwater recharge/return-flow to the river Beas and river Satluj due to river water and groundwater interaction.
5. Assessment of artificial recharge measures.

Statement of the Problem

As per report of CGWB, 80% area of Punjab falls under over-exploited zone. The concentrated pumping has affected the natural groundwater conditions and flow regime. The falling water table has brought the agricultural productivity and economic conditions of the state to a plateau. Recent isotopic hydrological investigations have provided some clues on recharge conditions of groundwater diminishing zone in Bist doab. However, most of the isotope data in the earlier study was based on top aquifer and few data from a second aquifer, while the wells getting developed for irrigation and drinking needs have been entering into the deeper aquifers. The doab region is underlain by hundreds of meters of thick alluvium. However, the detailed study of groundwater age of deeper aquifer is yet to be mapped using ^{14}C dating. The present study is intended to assess the mid and long term sustainability of groundwater resources, especially in aquifers that have been providing large quantities of water over last few decades. The study region will be an extended part of Bist doab region where groundwater is getting over-exploited.

Action Plan

Year	October 2013 to March 2014	Remarks
April 2013 to March 2014	Water sampling, analysis and data interpretation Report writing	Report preparation as per table below.

Activity Schedule (Quarterwise: October 2013 to March 2014)

Activity	1st	2nd
Review and synthesis of groundwater data, isotope data and hydro-chemical data, as on date	♦	♦
Water sampling from piezometers and deep wells for water quality and stable isotope analysis	♦	♦
Groundwater age dating investigations		♦
Suggesting management measures to improve groundwater conditions in the region		♦
Interim report		♦

Work and Progress

In order to investigate groundwater and surface water interaction, groundwater sampling stations have been established at 3 cross-sections over a length of 2 km. along the river Beas (i) stations in the northern side of Beas: Tangru, Damtal, Kathgarh, Mirthal, Jagatpur Kalan, Dhaki, (ii) stations in the central side: Hargovindpur, Machrai, Ghuman, (iii) stations in the southern side; Govindwal, Fatehabad. An interim report for the progress of 2012-13 was submitted to IAEA.

Study Benefits /Impact

Improved understanding of groundwater dynamics in shallow and deep aquifer

- Thematic maps of spatial distribution of isotopic, hydro-geological and quality aspects of groundwater
- Research publications and report

Specific linkages with Institutions: IAEA, Vienna

11. PROJECT REFERENCE CODE: NIH/HID/MOES/2012-15

Title of the Study : **The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates**

Study Team : S. P. Rai (PI)
M. S. Rao
Surjeet Singh
S. K. Verma
C. P. Kumar
Sudhir Kumar
V. K. Agarwal
Rajeev Gupta
S. L. Srivastava
Vishal Gupta
Mohar Singh

Type of Study : Sponsored

Funding Agency : MoES, Government of India

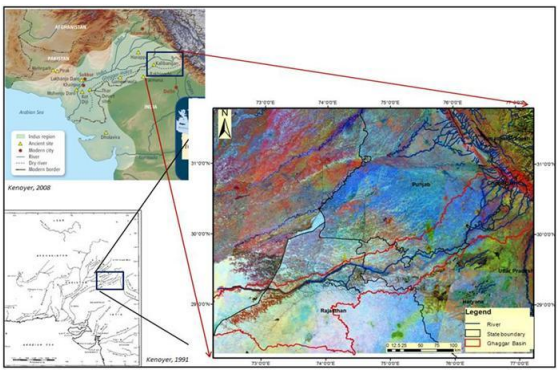
Budget : Rs. 210 Lakh

Date of Start : June 2012

Date of Completion : May 2015

Location Map

The study area covers the North Western India. However, Ghaghar basin has been selected to carry out detailed investigations, which covers the states of Himachal Pradesh, Punjab, Haryana and Rajasthan.



Land use: Agriculture dominated

Major problem of the area is declining of groundwater levels at a very fast rate, but at few places groundwater level is rising also.

Study Objectives

(a) Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water
(b) Groundwater dating using Tritium and Carbon-14
(c) Measurement of Radon in groundwater
(d) Delineation of flow direction and recharge zones
(e) Identification of recharge source and zones of groundwater in the study area

Statement of the Problem

India is largest agricultural user of groundwater in the world. The last 40 years have seen a revolutionary shift from large scale surface water management to widespread groundwater abstraction, particularly in the northwestern states of Punjab, Haryana and Rajasthan. As a result of this, groundwater depletion of this region has become under the vulnerable condition and a hotspot for groundwater management. The groundwater depletion rates in the states of northwestern India are reported highest in the world. This unmanaged use of groundwater becomes more challenging due to increasing demands from population and industrial developments under the climate change scenario. There is a major task to replenish the groundwater depletion through rainfall recharge. Therefore, this study is proposed to study groundwater dynamics in the region.

Action Plan

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Selection of study area	♦											
Literature survey	♦	♦	♦	♦	♦							
Collection of previous years data	♦	♦	♦	♦	♦							
Identification of data gaps	♦	♦	♦									
Selection of sites for stable isotope (δ^2H and $\delta^{18}O$) analysis	♦	♦	♦									
Selection of sites for radio-isotope (^3H and ^{14}C) analysis	♦	♦	♦									
Site selection and installation of raingauges	♦	♦	♦									
Measurement of δ^2H and $\delta^{18}O$ of rain, river and groundwater		♦	♦	♦	♦	♦	♦	♦	♦	♦		
Measurement of ^3H and ^{14}C activity of groundwater, rain and river		♦	♦	♦	♦	♦	♦	♦	♦	♦		
Measurement of radon in groundwater		♦	♦	♦	♦	♦	♦	♦	♦	♦		
Preparation of geological and hydrogeological maps of the study area				♦	♦	♦	♦	♦				
Preparation of water table and flow direction map on the basis of previous years data		♦	♦	♦	♦	♦						
Interpretation of isotopic data					♦	♦	♦	♦	♦	♦	♦	
Estimation of natural recharge to groundwater									♦	♦	♦	
Impact of climate change on groundwater			♦	♦	♦	♦	♦	♦	♦	♦	♦	
Identification of recharge zones									♦	♦	♦	

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
First Draft Report										♦		
Second Draft Report											♦	
Final Report												♦

Objectives vis-à-vis Achievements

Objectives	Achievements
• Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water • Groundwater dating using the tritium and Carbon-14 • To decipher the recharge zone of springs falling in the study area • Measurement of Radon in groundwater • Delineation of flow direction and recharge zones • Identification of recharge source and zones of groundwater in the study area.	• Samples of groundwater, river and canal have been collected for isotopic analysis. • To date the groundwater, samples for tritium analysis have been collected. • Radon measurement is under progress.

Analysis and Results

Isotopic Composition of Rainfall, River and Canal Water

The $\delta^{18}O$ of precipitation varies from -13.3‰ (minimum) to 5.3‰ (maximum) and $\delta^{2}H$ from -105.2‰ (minimum) to 44.0‰ (maximum). The local meteoric water line is

$\delta^{2}H = 7.86 * \delta^{18}O + 5.4$, $r^2 = 0.98$, n = 148

Ghaggar river samples have been collected from its origin near to Nahan in Himachal Pradesh to downstream upto Sirsa in Haryana. The $\delta^{18}O$ of river varies from -7.3‰ to -5.3‰ and $\delta^{2}H$ vary between -50.6‰ and -46.4‰. The canal water samples were collected from various sites in the catchment. The isotopic variations of canal water are found between 12.1‰ and -11.5‰ for $\delta^{18}O$ and -79.1‰ and -74.9‰ for $\delta^{2}H$. The groundwater samples were collected from existing dug wells, hand pumps and tube wells. The dug wells, hand pumps and tube wells represent different depths of water levels. The oxygen isotopic ratio ($\delta^{18}O$) of water samples up to depth of 30 m varied from -11.7‰ (minimum) to -5.1‰ (maximum) and hydrogen isotopic ratio ($\delta^{2}H$) from -81.4‰ (minimum) to -34.6‰ (maximum). The $\delta^{18}O$ of water samples collected from the depth of 30 to 60 m varied from -12.6‰ (minimum) to -3.1‰ (maximum) and $\delta^{2}H$ from -84.8‰ (minimum) to -28.6‰ (maximum). The $\delta^{18}O$ of water samples below the depth of 60 m varied from -8.5‰ (minimum) to -4.9‰ (maximum) and $\delta^{2}H$ from -60.0‰ (minimum) to -27.8‰ (maximum).

The spatial variation of $\delta^{18}O$ values of groundwater at shallow depth show that $\delta^{18}O$ vary between -4‰ and -11‰. The enriched $\delta^{18}O$ values have been found in upper part of the catchment while depleted values in the middle and lower parts of the catchment. The depleted isotopic signature of groundwater in the middle and lower parts indicates recharge to groundwater through canal water.

The environmental tritium activity has been measured for groundwater at different locations and it is found to vary between 0.3 TU and 8 TU. The tritium value of groundwater samples collected from shallow depths near Chandigarh and Rajpura area are varying from 5.2 TU to 6.1 TU and near Patiala and Samana it is about 4.2 TU.

Future Plan

- Post-monsoon sampling of groundwater for stable and radio isotope measurements, rainfall sampling to continue
- Preparation of drainage map of the study area
- Preparation of hydrogeological map of the study area
- Analysis of water level data

12. PROJECT REFERENCE CODE: NIH/HID/BGS/2013-14

Title of the Study	:	**Review of Groundwater Resources in the Indo-Gangetic Basin: A Case Study on Resilience of Groundwater in the Punjab to Withdrawal and Environmental Change**
Study Team	:	M. S. Rao (PI) C. P. Kumar Gopal Krishan
Type of Study	:	Sponsored
Funding Agency	:	BGS-DFID
Budget	:	£ 24,360
Date of Start	:	February 2013
Date of Completion	:	May 2014

Location: Indo-Gangetic basin (Punjab, Haryana, UP, Bihar and West Bengal)

Study Objectives

1. Overview of the occurrence and status of groundwater resources in the Indo-Gangetic Basin (IGB)
2. To carry out a case study examining the residence times of groundwater across a rainfall transect in heavily exploited, Punjab

Statement of the Problem

The Indo-Gangetic plains support one of the most populous areas on the earth. It is home to approximately one billion people. The economy, poverty and health of the region are highly diverse and include areas of extreme poverty as well as highly successful and growing economies. Exploiting easily accessible water resources for drinking water, agriculture and growing industries has been fundamental to the region's success and will continue to play a large part in its future. Despite the presence of the large rivers, groundwater is highly exploited across the basin. Within the Indo-Gangetic basin, groundwater condition has reached to most critical condition in Punjab. As per assessment of the Central Ground Water Board (2009), the stage of groundwater development of Punjab state is 170% leaving little scope for further development of dynamic resource except in few pockets. Gravity of the situation can be gauged from the fact that stage of groundwater utilization exceeded 300% in some parts of the north-east Punjab.

Considering these facts, it is proposed to prepare a report on groundwater availability in the Indo-Gangetic basin and to examine the case in detail across heavily exploited region of Punjab.

Work and Progress

This project is broadly divided into two parts: (i) groundwater resilience in Ganga basin, and (ii) detailed case study in parts of Punjab (Bist-doab).

For the first part on groundwater resilience in Ganga basin: the basin boundary map, drainage pattern (rivers and canals), administrative boundaries etc. has been digitized in the Google Earth frame. In the literature survey on the Ganga basin, the following topics have been covered: state wise share of the basin area, distribution of the drainage area, intensity of irrigation, polluted stretches of river within Ganga basin; catchment area, annual water yield, mean flow rates of Ganga basin; stream characteristics, water quality, seasonal variation of the Ganga river and its major tributaries; soil types, land use pattern, distribution of cultivable area within Ganga basin; distribution of towns and cities, diversion projects, storage projects for hydroelectricity generation and major irrigation projects within Ganga basin.

For the second part on detailed case study on Bist doab, Punjab: a total of 19 paired groundwater samples were collected from the deeper and shallow aquifers (tubewells and groundwater wells) on the basis of results obtained in the ongoing PDS study on Bist doab in two field visits along with the officials of BGS. The groundwater samples were analysed for stable isotopes ($\delta^{18}O$ and δD) using IRMS. Analysis of water quality through Ion Chromatograph (at NIH) and analysis for groundwater dating using CFC and SF_6 (at BGS, UK) are in progress (these techniques are initiated for the first time in NIH). Using this, groundwater recharge areas, recharge rates, recharging water temperature and flow conditions will be examined.

The interim report will be prepared and presented in the 1st review meeting scheduled to be conducted in New Delhi during November 4-8, 2013.

Publications: 01

G. Krishan, D. J. Lapworth, M. S. Rao, C. P. Kumar, M. Smilovic and P. Semwal. 2013. Natural (baseline) groundwater quality in the Bist-doab catchment, Punjab, India: A pilot study comparing shallow and deep aquifers (accepted for presentation in International Conference AWRDM-2013, to be held at Panjab University, Chandigarh during October 23-27, 2013).

Action Plan

Year	October 2013 to May 2014	Remark
October 2013 to May 2014	Literature review on available groundwater studies including water table, water quality and other hydro-geological aspects falling within the Indian portion of the IGB Preparation of a status report on groundwater issues in IGB (only for the Indian portion) Presentation of work progress in a workshop/ review meeting under the project Field sampling of a transect using isotopes and residence time indicators in conjunction with specialist team from BGS to investigate resilience	Report preparation as per table below.

	of groundwater in Punjab to withdrawal and environmental change Fabrication of sampling units for groundwater collection for CFC, SF_6 and noble gas analysis	

Activity Schedule (Quarter-wise from October 2013 to May 2014)

Activity	1st (Oct 2013 –Jan 2014)	2nd (Feb-Apr 2014)
Sampling	♦	♦
Collection of data from various agencies (NIH)	♦	♦
Recharge studies in unsaturated zone including sampling and analysis		♦
Analysis of isotopic and CFC, SF6, Noble gases (NIH-BGS)	♦	♦
Water quality analysis of samples (NIH-BGS)	♦	♦
First draft (NIH-BGS)		♦

Study Benefits /Impact

- An overview report on groundwater resilience in IGB
- Report on resilience of groundwater in Punjab to pumping and environmental change
- Research publications in high impact journals
- Upload of results on website
- Acquiring of new technology for groundwater study (CFC, SF_6 and noble gas analysis)

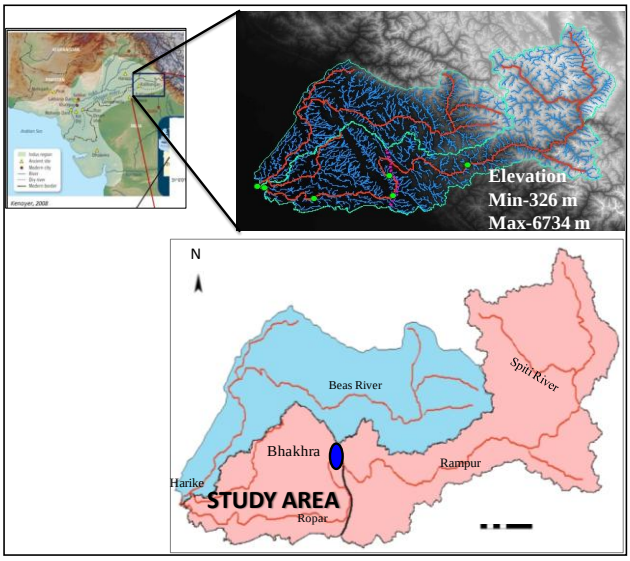
Specific linkages with Institutions: BGS, UK

13. PROJECT REFERENCE CODE: NIH/HID/IAEA-2/2012-15

Title of the Study	:	**Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques**
Study Team	:	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar V. K. Agarwal Vishal Gupta Mohar Singh
Type of Study	:	Sponsored
Funding Agency	:	IAEA, Vienna
Budget	:	5000 Euro per year
Date of Start	:	October 2012
Date of Completion	:	September 2015

Location Map

The study area falls in the Punjab state of India. Groundwater levels in Punjab have reached to most critical condition. As per report of Central Ground Water Board, Government of India (2009), 80% area of Punjab state falls under over-exploited zone. With onset of Green Revolution during 1960s, the state rapidly adopted the green revolution technology and resulted in increased demand for irrigation water. The requirement of irrigation was met through development of irrigation canal network and development of tube wells. Between 1960 and 1999, the food grain production of Punjab increased from 3.16 to 22.22 million tones. During this period, number of tube wells increased from 0.60 million to 1.1 million, leading to over-exploitation of groundwater in most parts of the state. The concentrated pumping has affected the natural groundwater conditions and flow regime.



Study Objectives

- To develop thematic maps based on isotope and related information relevant to the evaluation and assessment of the quality of surface water

- Comparative study of recession characteristics of Satluj River with conceptual and isotopic model

(f) To assess the potential and limitations of the tracer techniques for routine application in hydrological studies

Statement of the Problem

The importance of Satluj river in Indian context is better understood from the fact that it continues to play a major role in the socio-economic development of north-western part of the country. The dependency of the states of Himachal Pradesh, Punjab, Haryana and Rajasthan on the resources of Satluj river for the sustenance and growth of agricultural and hydroelectric power sector is ever growing. In addition to several micro and mini projects, several mega projects are under way, particularly in the upper part of Satluj Basin. The runoff of Satluj river receives major contribution from snow/glacier, rainfall-runoff and groundwater/baseflow. The assessment of rainfall derived runoff and snow and glacier melt runoff have been carried out. However, contribution of the baseflow to river flow was overlooked and no major attempt has been made to assess the impact of baseflow contribution on discharge and quality of the river. Therefore, this study will be a first approach to understand the groundwater and river interaction in this part of the Satluj catchment.

Action Plan

Activity Schedule (Quarterwise: 2012-13, 2013-2014 and 2014-2015)

Activity	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**
Selection of study area			♦									
Literature survey			♦	♦	♦							
Collection of previous years' data				♦	♦							
Identification of data gaps				♦								
Selection of sites for stable isotope (δ^2H and $\delta^{18}O$) analysis					♦	♦	♦	♦				
Selection of sites for radio-isotope (^3H and ^{14}C) analysis			♦	♦	♦	♦	♦	♦	♦	♦		
Site selection and installation of raingauges			♦	♦	♦	♦						
Measurement of δ^2H and $\delta^{18}O$ of rain, river and groundwater				♦	♦	♦	♦	♦	♦	♦		
Measurement of ^3H and ^{14}C activity of groundwater, rain and river				♦	♦	♦	♦	♦	♦	♦		
Measurement of radon in groundwater								♦	♦	♦		
Preparation of geological and hydrogeological maps of the study area				♦	♦	♦	♦	♦				

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Preparation of water table and flow direction map on the basis of previous years' data				♦	♦	♦						
Interpretation of isotopic data					♦	♦	♦	♦	♦	♦	♦	
Application of conceptual model					♦	♦	♦	♦	♦	♦	♦	

Objectives vis-à-vis Achievements

Objectives	Achievements
• Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water • Groundwater dating using tritium and Carbon-14 • Comparative study of recession characteristics of Satluj river with conceptual and isotopic model • Delineation of flow direction and recharge zones • Comparative study of recession characteristics of Satluj river with conceptual and isotopic model	• Samples of groundwater, precipitation, river and canal collected for isotopic analysis • To date groundwater, samples for tritium analysis collected • Radon measurement in progress

Analysis and Results

Isotopic Composition of Precipitation

The isotopic composition of weighted average of precipitation in study area varies from -13.3‰ to 4.2‰ for $\delta^{18}O$ and -105.2‰ to 41.4‰ for $\delta^{2}H$. The $\delta^{18}O$ of Satluj river vary between -13‰ to -10‰ and $\delta^{2}H$ from -91‰ to -68‰. The depleted isotopic composition of Satluj river indicates that it is derived from higher Himalayas.

The oxygen isotope ratio ($\delta^{18}O$) of groundwater samples up to depth of 30 m varied from -13.0‰ (minimum) to -4.6‰ (maximum) and hydrogen isotopic ratio ($\delta^{2}H$) from -88.8‰ (minimum) to -32.4‰ (maximum). The spatial distribution of isotopic composition of shallow and deep groundwater has been studied. Generally, shallow groundwater show enriched $\delta^{18}O$ and $\delta^{2}H$ values in the study area. However, at few locations, depleted value (more than -9‰) are also found due to possible recharge through river/canal. The deep aquifer shows almost similar isotopic composition throughout the study area which resembles the isotopic composition of precipitation. The chemical and isotopic samples are under progress.

Future Plan

- Sampling of groundwater, rain and river water to continue
- Isotopic characterization of rain, river and groundwater
- Hydrochemical characteristics of groundwater and river
- Hydrograph separation to separate out baseflow component
- Identification of groundwater discharge and recharge zones to Satluj river
- Progress report and recommendations

14. PROJECT REFERENCE CODE: NIH/HID/IAEA-3/2013-15

Title of the Study	:	**Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains**
Study Team	:	Dr. Sudhir Kumar (PI) Dr. S. P. Rai Dr. C. K. Jain Mr. P. K. Garg
Type of Study	:	Sponsored
Date of Start	:	May 2013
Date of Completion	:	April 2015

Location Map: Same as at Project no. NIH/HID/INT/2013-15/2

Study Objectives

1. To identify various aquifers present in alluvial tract of the Upper Yamuna Plains
2. To identify the source of recharge of different aquifers and the interaction between various aquifers
3. To investigate the continuity of aquifers on both sides of the Yamuna river
4. To determine the groundwater dynamics in different identified aquifers
5. To estimate the groundwater velocity and replenishment potential of the deeper aquifers

Statement of the Problem

Groundwater is the backbone of India's agriculture and drinking water security. It is a common-pool resource, used by millions of farmers across the country, remains the only drinking water source in most of India's rural households, and supports industrial water demand in many cases. The scarcity of water resources and ever increasing demands underline the importance of identifying, quantifying and managing groundwater to offset the problems of over-extraction and contamination. For better management of aquifers, the disposition and inter-relationship between various aquifers and streams is desired to be understood.

In this direction, Central Ground Water Board, Government of India has started an ambitious program for mapping the aquifers in India. This program is designed to make a significant step forward in groundwater resource management by identifying and mapping aquifers, quantifying the available groundwater resources potential and proposing plans appropriate to the scale of demand, aquifer characteristics and the institutional arrangements for management.

The proposed area for the research project shall be Upper Yamuna Plains covering Meerut, Baghpat, Shamli, Muzzafarnagar and Saharanpur districts of Uttar Pradesh and Jind, Panipat, Sonipat, Karnal, Kurukshetra, Kaithal, and Yamunanagar districts of Haryana, where groundwater table is reported to be falling at a faster rate (approx. 1 m/year).

Action Plan

Activity	Quarters							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Collection of available literature and data from CGWB and State Groundwater departments	*							
Identification of wells for groundwater sampling	*							
Construction of aquifer geometry based on available data/information		*						
Collection of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis		*	*		*			
Chemical and stable isotopic analysis of samples		*	*		*	*		
Tritium samples analysis and dating		*	*	*	*	*		
Collection and analysis of samples for ^{3}H-He dating				*	*	*		
Collection and analysis of samples for ^{14}C dating		*	*	*	*	*		
Interpretation of data			*	*	*	*	*	
Report finalization							*	*

Objectives vis-à-vis Achievements

1. Most of the data available with CGWB has been collected.
2. Wells for groundwater sampling have been identified.
3. First round of sampling has been completed from UP side of the study area.
4. Construction of aquifer geometry based on available data / information is under progress.
5. Analysis of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis is under progress.

Analysis and Results

1. Aquifer geometry is being finalized from the data collected from CGWB.
2. Samples for isotope and geochemical analysis collected and analysed.

Future Plan

1. Sampling for Tritium, Carbon and Tritium-Helium dating
2. Analysis of samples

SURFACE WATER HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. Rakesh Kumar	Scientist F & Head
2	Dr. J V Tyagi	Scientist F
3	Dr. Avinash Agarwal	Scientist F
4	Dr. R P Pandey	Scientist F
5	Dr. A K Lohani	Scientist F
6	Dr. Senthil Kumar	Scientist D
7	Dr. Sanjay Kumar	Scientist D
8	Smt. Archana Sarkar	Scientist C
9	Dr. Manohar Arora	Scientist C
10	Sri Digambar Singh	Scientist B
11	Sri J P Patra	Scientist B
12	Sri Naresh Kumar	PRA
13	Sri N K Bhatnagar	PRA
14	Sri R K Neema	SRA
15	Sri Hukum Singh	SRA
16	Sri Om Prakash	SRA
17	Sri S L Srivastava	SRA
18	Sri T R Sapra	RA

WORK PROGRAMME FOR THE YEAR 2013-14

S. No. & Ref. Code	Title	Study Team	Duration
Internal Studies			
1. NIH/SWD/ NIH/10-13	Climatic variability analysis and its impact on Himalayan watershed in Uttarakhand	A. Agarwal, Manohar Arora R K Nema	3 years (Nov. 10 – Oct. 13)
2. NIH/SWD/ NIH/08-	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	March 08 -To be continued
3. NIH/SWD/ NIH/11-14	Hydrological Studies for Upper Narmada Basin	Jagdish P. Patra Rakesh Kumar Pankaj Mani T R Sapra	3 years (April 11 – March 14)
4. NIH/SWD/ NIH/12-15	Study of Hydro-Meteorological Droughts for Bundelkhand Region in India	R.P. Pandey	3 years (April 12- March 15)
5. NIH/SWD/ NIH/12-15	Sedimentation Studies for Pong Reservoir, Himachal Pradesh	A. R. S. Kumar, Manohar Arora Suhas D Khobragade, A. Agarwal, Sanjay K. Jain	3 years (April 12 – March 15)
6. NIH/SWD/ NIH/13-14	Development of Real Time Flood Forecasting for downstream of Hirakud dam	A.K. Lohani	One year (April 13- March 14)
7. NIH/SWD/ NIH/13-15	Application of DSS(P) for Integrated Water Resources Development and Management	A.K. Lohani Surjeet Singh Rahul Jaiswal	2 year (April 13- March 15)
8. NIH/SWD/ NIH/13-14	Status Report on Soil Erosion and Sediment Transport Modelling	J.V. Tyagi	One year (April 13- March 14)
9. NIH/SWD/ NIH/13-16	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3 year (April 13- March 16)
10. NIH/SWD/ NIH/13-16	Suspended Sediment Flux Modelling in the largest sub-basin of Brahmaputra	Archana Sarkar Rakesh Kumar	One year (April 13- March 14)

1. PROJECT REFERENCE CODE: NIH/SWD/NIH/10-13

a) Title of the study: **Climatic variability analysis and its impact on Himalayan watershed in Uttarakhand.**

b) Study Group: Avinash Agarwal, Sc F & P.I., SWH Div.
Manohar Arora Sc C & Co.P.I., SWH Div.
R K Nema, SRA, SWH Div.

c) Type of study: Internal

d) Date of start: Nov. 2010

e) Scheduled date of completion: Oct. 2013

f) Location map / study area:

Study area of this project lies in 'Western Himalaya' agro-ecological region of the Sub-humid ecosystem at elevation of 720 m to 2350 m. Climate in this region is warm with air temperature 3^{o}C to 35^{o}C sub-humid to humid and per-humid with average annual rainfall 900 mm to 1200 mm respectively for Chandrabhaga and Danda watersheds (Uttarakhand). Reliable source of water in the watersheds is only the existing springs in the watersheds.

g) Objectives of the study:

i. Development of rainfall-runoff, rainfall-spring flow relationships and assessment of climatic variability.
ii. Estimation of impact of climatic variability on runoff and spring flow.
iii. Detailed hydrological monitoring, collection of data at watershed scale and creation of a centralized database for watershed for the benefit of the users.
iv. Development of implementable technology for water availability and transfer of developed technology to users.

h) Statement of the problem:

The monitoring continued with a network of instrumentation for watersheds (Chandrabhaga, Danda) with Rainfall (08 locations), runoff (3 locations), AWS One location for rainfall, temperature, humidity, wind speed & direction incoming radiation, pan evaporation and soil moisture (different depths), soil temperature (two depths). Daily spring flow of around twenty locations in each watershed.

i) Approved action plan:

Year	1st quarter (A M J))	2nd quarter (J A S)	3rd quarter (O N D)	4th quarter (J F M)
2010			Maintenance and up keeping of installed equipments	Processing and analysis of data collected during 2010
2011	Interactive workshop	Literature review and development of model	Interpretation of results	Processing and analysis of data collected during 2011

2012	Development of appropriate model	Interactive workshop	Interpretation of results	Processing and analysis of data collected during 2012
2013	Analysis of current data with historical data	Interactive workshop	Preparation of report	

j) Role and Responsibility of Team Members:

Dr. Avinash Agarwal (PI): Field visits, collection of electronic data, processing and plotting of data. Analysis of rainfall, runoff spring flow data. Development of implementable technology for water availability and transfer, progress presentation and final reporting.

Dr. Manohar Arora (Co PI): Field visits. Assessing in collection of electronic data and in development of implementable technology for water availability analysis. Presenting the progress of work when required. Transfer of technology

R K Nema (Sc. Asstt.): Field visits. Collection of tabulated data. Keeping the record of skilled and unskilled daily wages. Proper running of all field instrument and observatory. Visits of the sites for its proper up date. Assessing in transfer of technology

k) Recommendation and suggestions in previous meeting of working group:

No specific comments/ recommendation.

l) Analysis of results:

i. Maintenance and up keeping of installed equipments.
ii. The collected data for the year is under processing.
iii. Rainfall, runoff and spring flow data has been analyzed for different relationships and for climatic variability assessment.

m) Results in brief:

- **Maintenance and up keeping of installed equipments.**
- **Rainfall runoff and spring Flow analysis.**

Monthly rainfall runoff relationships are developed for monsoon, non-monsoon and total period. Long term watershed variability has been identified. Monthly cumulative rainfall and spring flow indicated a high correlation for all springs in both the watersheds. Total rainfall and spring flow is also highly correlated. Spring classification is done on the basis of maximum flow and long term behavior. The recession of the springs can be given with polynomial, power and log relationship. Generalized relationships are developed for both watersheds. Rain to spring lag on daily and monthly basis is identified. Spring flow variability is related with spring lag.

- **The data collected up to June 2013 is utilized for analysis and report writing is under process.**

n) **List of deliverables:** Hydro-meteorological data, papers and report for small watershed of Uttarakhand.

o) **Major items of equipment procured:** Nil

p) **Lab facilities used during the study:** Nil

q) **Data procured and /or generated:** The data hub for the watersheds has been updated and report is under progress.

r) **Study benefits/impacts:** Hill habitat and State Government and other agencies.

s) **Specific linkage with institutions and/or end-users/ beneficiaries:** Village wise interactive workshops in the watershed are proposed

t) **Shot comings/ difficulties:** Nil

u) **Future plan:** As proposed in the action plan.

2. PROJECT REFERENCE CODE: NIH/SWD/NIH08-

a) Title of study: **Monitoring and Modelling of Streamflow for the Gangotri Glacier**

b) Study group: Manohar Arora Sc 'C', SWH Div.

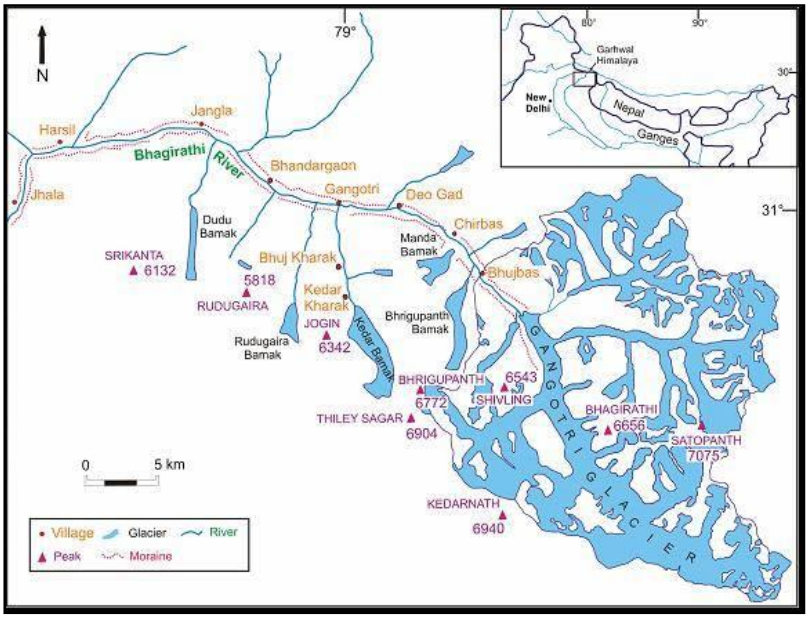
Rakesh Kumar Sc 'F', SWH Div.

c) Type of study: Internal

d) Date of start: 01.04. 2008

e) Scheduled date of completion: Long term study

f) Location map:



g) Objectives of the project:

The objective of this study includes:

i. Continuous monitoring of meteorological and hydrological data for monthly and seasonal specific water yield and its variability from the year to year

ii. To improve the hydrological model for simulating daily streamflow

h) Statement of the problem:

The study involves collection and analysis of hydro-meteorological and discharge data of the glacier site. The second step is to develop and apply a snow melt model for streamflow generation and identification of different runoff components.

i) Approved action plan:

Year	May to October	Nov. to April	Remark
All Years	Field investigations & Data Collection	Data analysis	Report preparation after three years

j) Role and Responsibility of Team Members:

i. **Dr . Manohar Arora, Scientist C& PI:** Conduction field investigations, analyzing data/information, report preparation and overall responsible for the study completion.
ii. **Dr Rakesh Kumar, Scientist F & Co-PI:** Guidance in development of methodology, modelling and structuring of report.

k) Objectives vis a vis Achèvements:

Objectives	Achèvements
Continuous monitoring of meteorological and hydrological data for monthly and seasonal specific water yield and its variability from the year to year	The data collection and field investigations for the summer 2013 were completed. The analysis has been completed for the collected data.
To improve the hydrological model for simulating daily streamflow	The simulation of flow will be carried out after collection of three years of data.

l) Recommendations of Working Group/TAC/GB:

The study may be continued for long term to link with climate change.

m) Analysis and Results:

In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides, which resulted in massive loss of lives and property. In the study, the hydro-meteorological and discharge data for 14 June 2013 to 18 June 2013 collected at an observatory near the snout of the Gangotri glacier has been analysed. This area normally receives less rainfall and the maximum monthly rainfall of the month for June during previous years hardly exceeded 93 mm, while total rainfall during this 5-day storm was 178 mm. Sudden increase of water discharge in the river resulted in flooding downstream. Flows at the gauging site peaked at 163 m^3 s^{-1} on 16th June 2013. It is observed that the mean runoff depths of June varied between 12-14 mm whereas runoff depths recorded up to the site was highest on 16th June 2013.

n) Adopters of the results of the study and their feedback:

The study is a part of long-term action plan on climate change by the Institute.

o) List of deliverables:

1. The interim report for 2011 – 2012 was prepared and submitted.
2. Research papers are being brought out.

p) Major items of equipment procured: Nil

q) Lab facilities during the study: Analysis of suspended sediment samples in Soil Lab.

r) Data generated in the study: Meteorological and hydrological data for the Gangotri Glacier.

s) Study Benefits/Impact: The study is being conducted under the long term action plan on climate change as per instructions of MOWR. The meteorological and discharge data would be utilised in studying the characteristics of the Gangotri glacier under changing climate.

t) Specific linkages with Institutions/beneficiaries: The data collected is also being shared with the authorities of Gangotri National Park. The details of sediment concentration are being communicated to the downstream Dam authorities.

u) Shortcomings/Difficulties: The study involves four months of extensive field work and maintenance of construction site etc. Without the support of project staff it is difficult to manage data collection.

v) Future Plan: The study will be conducted for long term. The Himalayan glaciers are poorly monitored. There is very little or sparse data of Himalayan Glaciers The collected data will be used for climate change studies.

3. PROJECT REFERENCE CODE: NIH/SWD/NIH/11-14

a) Title of study: **Hydrological Studies for Upper Narmada Basin.**

b) Study group: Jagdish Prasad Patra, Sc. 'B' & PI SWH Div.
Rakesh Kumar, Sc. 'F' & Head SWH Div., Co-PI
Pankaj Mani, Sc 'D', CFMS, Patna
T R Sapra, S.R.A.

c) Type of Study: Internal

d) Date of start: April, 2011

e) Scheduled date of completion: March, 2014

f) Location map:

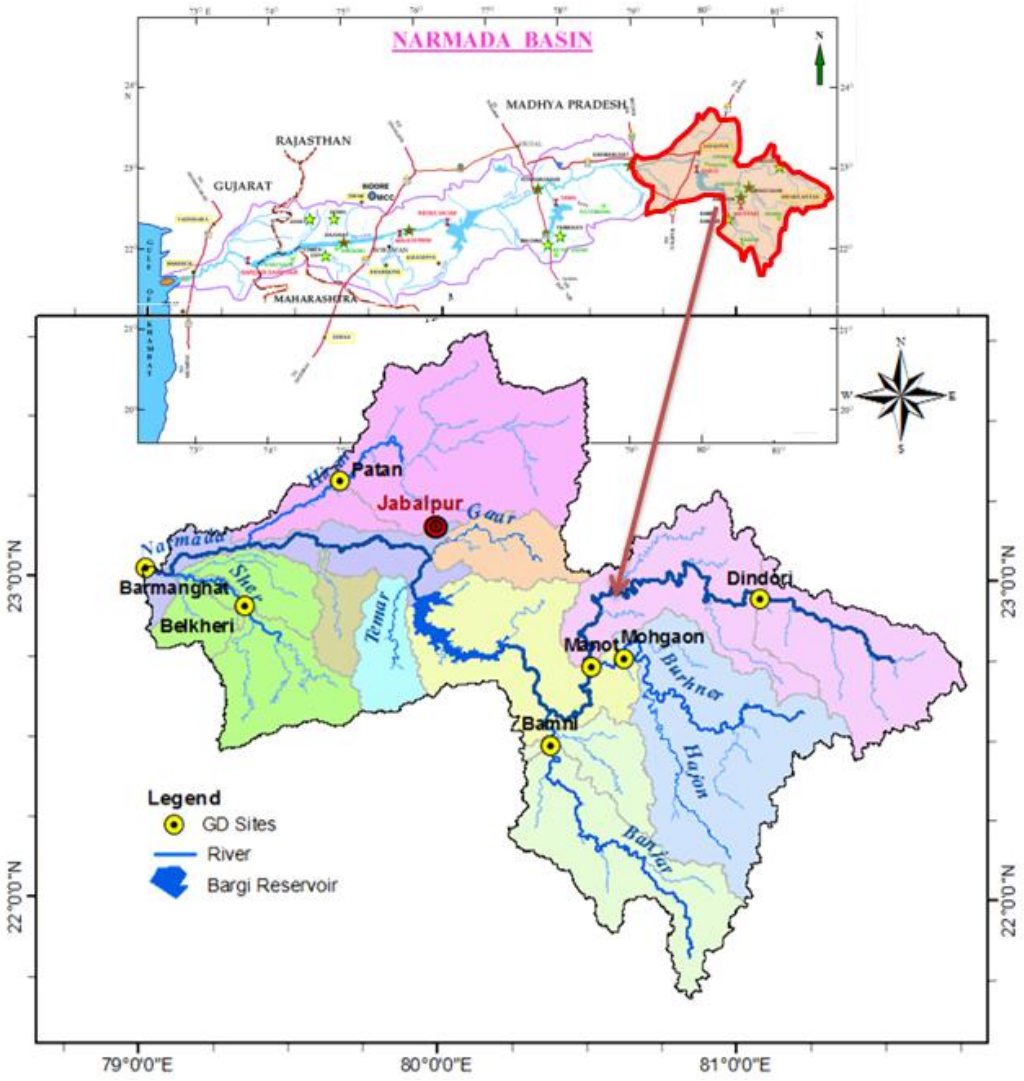


Fig. 1: Location map of study area.

g) Study objectives:

(i) Estimation of dependable flows for some of the gauging sites.

(ii) Rainfall runoff modelling.

(iii) Estimation of floods for various return periods using L-moment for gauged and ungauged catchments.

(iv) Estimation of Standard Project Flood (SPF) and Probable Maximum Flood (PMF) for Bargi dam.

(v) Dam break flood wave simulation.

(vi) Preparation of flood inundation maps for various dam break scenarios.

h) Statement of the problem:

The Narmada is the largest west flowing and seventh largest river of India. The basin, edging between Vindya and Satpuda ranges, extends over an area of 98,796 km^2. The Narmada rises from a Kund at an elevation of 1057m from Amarkantak in the Maikal hill in Shahdol district of Madhya Pradesh. Bargi Dam is one of the first completed Dam out of the chain of 30 major dams to be constructed on Narmada River in Madhya Pradesh. The dam construction work started in 1974 and was completed in 1990 when the dam was filled to its complete capacity. The height of the dam is 69 m and length 5.4 km. The reservoir is about 75 km in length and 4.5 km width, spreading over 267.97 km^2 area.

Though probability of dam failure extremely low, its occurrences can imply catastrophic consequences in downstream, including loss of human lives, properties, natural resources and so on. Therefore, significant predictive data on hypothetical flood events such as flood flows, flow velocities, depths and flood wave arrival times at specific locations downstream of the dam become some the most important pieces of information for disaster preparedness. Moreover, the National Water Policy, 2002 recognized the unavailability of Emergency Action Plans (EAP) for majors dams and stressed upon preparation of EAP for all large dams. Dam break analysis plays a major role in preparing EAP. The preset study focus on dam break analysis of Bargi dam and resulting flood inundation mapping up to barmangath with a drainage area of 26, 453 km^2.

i) Approved action plan and timeline:

Action	Time (month)						Status
	1-6	7-12	13-18	19-24	25-30	31-36	
Literature review Data collection							Completed
Processing and analysis of data							Completed
Modelling work							Under Progress
Reporting / Assessment of progress							Under Progress
Preparation final report							

j) Role and Responsibility of Team Members:

Sl No	Role / Action	Member/(s)
1	Data collection	JPP,TRS
2	Estimation of river flows of various dependability	RK
3	Estimation of basin parameters	JPP,PM
4	Estimation of floods for various return periods and PMF	RK, JPP
5	Hydrological modelling using HEC-HMS	JPP,RK
6	Dam Break analysis. Flood wave routing using MIKE-Flood and danger reach mapping	PM,JPP
7	Prepare flood inundation maps using ArcGIS	JPP,RK,PM

JPP = J. P. Patra; RK = Dr. Rakesh Kumar; PM = Pankaj Mani;TRS =T. R. Sapra

k) Brief methodology:

The river flow for some of the gauging sites for the upper Narmada river and its tributaries for various dependability will be estimated. HEC-HMS model will be used for rainfall runoff modelling. The model will be calibrated and validated with available historical events at some of the gauging sites. For estimating design floods the total basin area will be divided into smaller size (Area < 5,000 km^2) sub-basins in order to apply unit hydrograph (UH) techniques. In this study different UH techniques such as in CWC-flood estimation report and Clark's UH method will be used. HEC-GeoHMS software will be used for the delineation of basins, estimation of basin parameters then project will be exported to HEC-HMS for rainfall-runoff modelling of various critical sequences of the rainfall depths. Floods for various return periods will be estimated using L-moments approach for gauged and ungauged catchments. In addition PMF and SPF will be estimated for Bargi dam. The runoff generated at outlet of each sub basin will be routed to the dam. Dam break analysis of Bargi dam for various failure scenarios will be simulated using MIKE Flood and flood propagation along the river, relationship between peak discharge with distance and its effects in the downstream will be analyzed. Further, the model output will be used to prepare flood inundation maps.

l) Results achieved with progress/ present status:

During past six months analysis for failure of Bargi dam has been carries out. As it is an earth and masonry composite dam, the breach time of 2 hour has been assumed. The breach width is estimated based criteria of maximum of (i) dam width at foundation level, 73 m; (ii) width of 7 blocks, ~ 250 m, (iii) 2-5 times height of dam, i.e. 120-300 m. Thus breach width of 250 m is assumed. The trapezoidal shape of the breach section is assumed for earthfill dam with side slope of 1V:1H. The breach starts at top of dam (426.9 m) and the final breach level is 367.00 m i.e. river bed level has been considered. The simulated breach section is overlaid on the dam upstream cross section is shown in Figure 2. The final shape of breach section at Bargi given in Figure 3. The gradual failure of the earthen dam has been simulated in MIKE 11 by linear failure mechanism in the present study. In dam break analysis it is assumed that the reservoir is at FRL when the inflow enters into the reservoir which in turn raises the water level above the top of the dam and thus the dam fails due to overtopping. The sensitivity of the breach width is carried out for 150 m and 350 m. The sensitivity of time of breach is carried out for 3600 sec. (1 hr), 7200 sec (2 hr) and 18000 sec (5 hr) breach time.

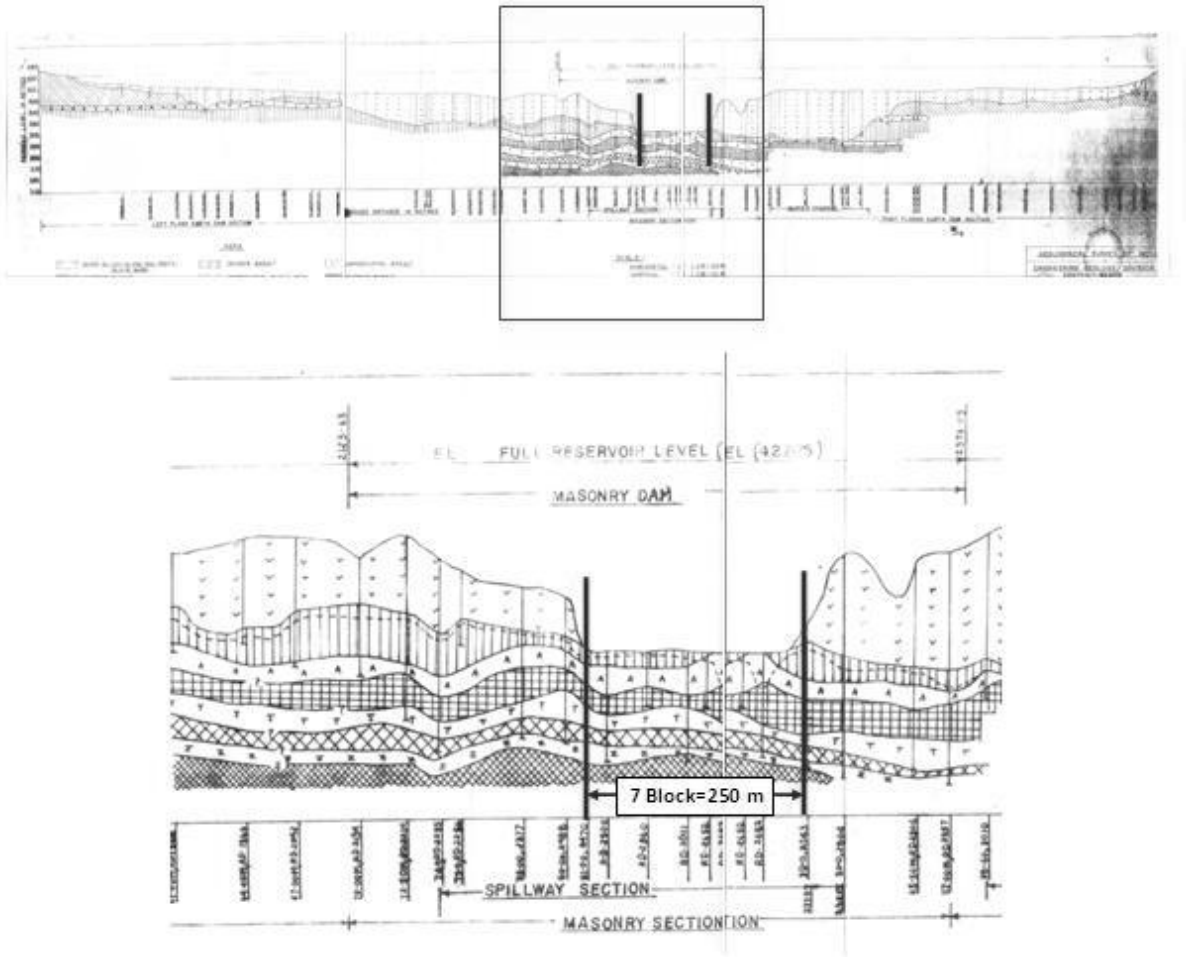


Fig. 2: Cross section of Bargi dam and probable breach size.

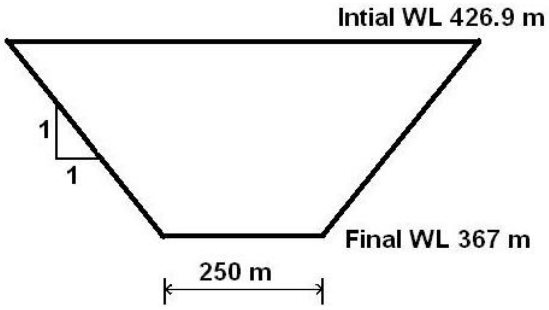


Fig. 3: Final breached section at Bargi dam.

m) Action taken on comments of previous working group meeting

There were no specific comments

n) List of deliverables:

Papers and reports.

o) Data collected/generated:

- DEM of the study area is generated from SRTM and contour of SOI toposheets.
- Land use and land cover map is generated by classifying LANDSAT image.
- Daily rainfall for six raingauge stations i.e., Jabalpur, Mandla, Umaria, Balaghat, Narsinghpur and Seoni for the year 1970 to 2007 are collected from IMD. However the data set is having missing values at some stations.
- Stage and discharge at eight gaugiging sites namely, Bamni, Barmanghat, Belkhedi, Bijora, Dindori, Manot, Mohgaon and Patan for the period of 2000 to 2010 from CWC.
- River cross-sections at above gauging sites are also collected from CWC.
- Measured some river cross-sections during field survey.
- Salient features of dam such as height, length, top-width, elevation of river bed etc, spillway characteristics, and elevation of uncontrolled spillway crest with discharge coefficients are collected from office of Chief Engineer (Bargi), Rani Avantibai Pariyojana, NVDA, Jabalpur (MP)
- Elevation capacity and area capacity curve of the reservoir, Inflow and outflow data from 1990 to 2010 are also collected from office of Chief Engineer (Bargi), Rani Avantibai Pariyojana, NVDA, Jabalpur (MP).

p) Involvement of end users / beneficiaries:

There has been discussion with the officials of Chief Engineer (Bargi), Rani Avantibai Pariyojana, NVDA, Bargi Hills, Jabalpur (M.P.) regarding need of this type of study.

4. PROJECT REFERENCE CODE: NIH/SWD/NIH/12-15

a) Title of the study: **Study of Hydro-Meteorological Droughts for Chitrakoot Bundelkhand Region in India**

b) Study group: R.P.Pandey**,** Sc F & P.I., SWH Div.

c) Type of study: Internal

d) Date of start: April 2012

e) Scheduled date of completion: March, 2015

f) Location map / study area:

Study area belongs to the part of Bundelkhand region in India (Fig. 1). Mean annual rainfall in the basin is about 1039 mm and mean annual potential evapotranspiration is about 1950 mm. Statement of problems of the study area is as follows:

- Paisuni basin in Chitrakoot faces recurrent droughts of with average frequency of once in five years (greater severity).
- Frequent failures of crops are reported in the basin due to droughts.
- Present sources of drinking water supply are not sufficient to meet the demand during summer. Sever water shortages emerge during drought period
- In recent past during 2004- 2008 and 2010, it experienced acute water scarcity due to persistent drought situation in the basin.
- Ground water availability in Manikpur, Pahari and Chitrakoot blocks are limited and it does not meet the demands. The Manikpur block appears to be more vulnerable to water shortages in summer months.

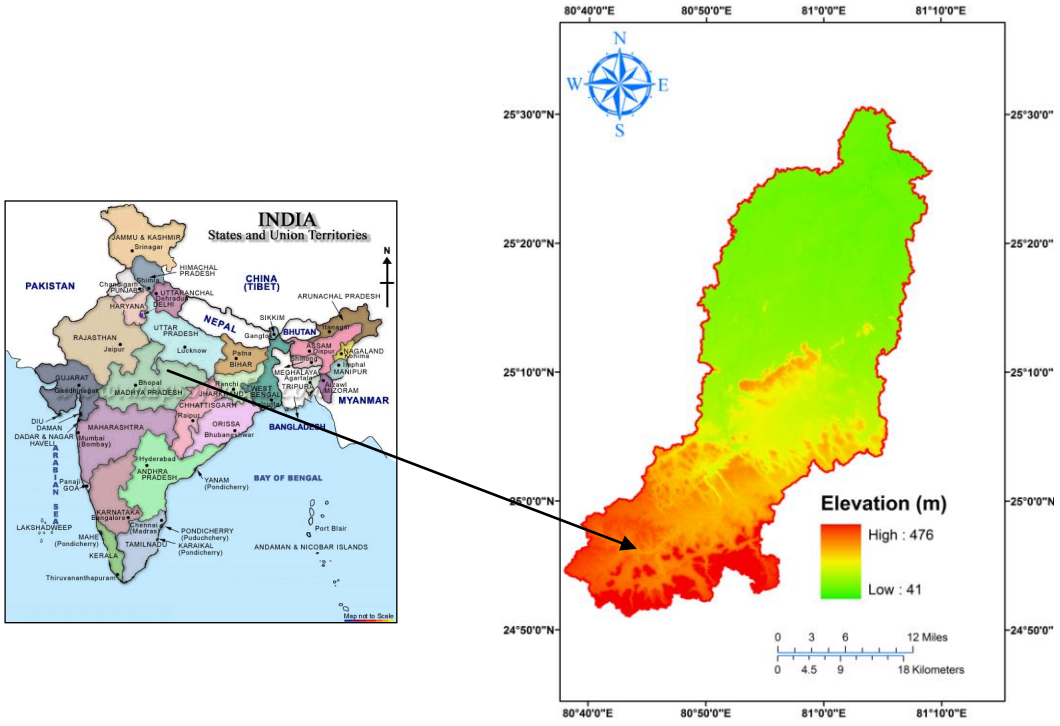


Fig. 1: Location Map of Paisuni Basin

g) Objectives of the study:

Major objective of the study is to quantify water scarcity during droughts and to identify possible options for augmenting water supply and minimizing crop loss due to droughts. The specific objectives of this project are to:

(i) Assessment of drought frequency, duration and severity in Bubdelkhand.
(ii) Quantification of surface water and groundwater availability.
(iii) Assessment of total water demands for domestic, industries and agriculture.
(iv) Assessment of supplemental irrigation to minimize crop loss due to dryspells and droughts.
(v) Delineation of zones vulnerable to different degree of drought severity.
(vi) To suggest an area specific plan for water management in Paisuni Basin,

h) Time schedule:

Item of work plan	Time Schedule
Field survey & data collection from study area	April-June, 2012
Procurement of meteorological data and stream flow data from IMD and CWC respectively..	April –Sept. 2012
Preparation of base maps	June –December 2012
Mid-term field investigations and crop survey	September 2012 – January 3013
Analysis of Rainfall Temperature, evaporation records	June 2012 –March 2013
Analysis of dry spells & regional drought characteristics	April 2013-Dec 2013
Preparation of drought vulnerability maps	January 2014- June 2014
Assessment of surface and groundwater availability and total demand	April 2014 -Dec 2014
Preparation of plan for water augmentation and storage requirements	January –February 2014
Preparation of report	January- March 2015

i) Progress of proposed study:

- Conducted field visit for collection of data/information collection from various sources in the proposed study areas.
- Procured GIS data in soft copy from Remote Sensing Application Centre, UP and collected daily rainfall data from district office.
- Prepared some of base maps of drainage, land-use, DEM, maps etc. using GIS.
- Procured various maps and Gazetteer and gathered other local information to prepare Inventory of past drought events in the study areas.
- Analyzed rainfall data to determine frequency and severity of droughts in past decades.
- Applied and compared SPI and EDI with A New Methodology (named as SDI, simple drought index) to assess attributes of drought events.
- Analyzed critical dry spell fro past 50 year data and estimated supplemental irrigation requirement for crop saving during CDS and drought.

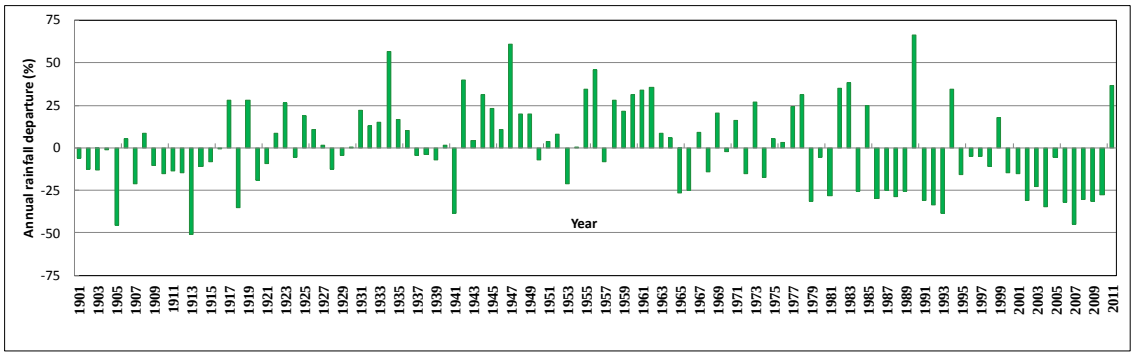


Fig: Annual Rainfall Departure 1901-2012.

Table : Results of Critical Dry Spell Analysis in Paisuni basin covering Chitrakoot distt. UP and Part of Satna distt. MP

S. No	Station	Ist Critical Dry Spell			IInd Critical Dry Spell			IIIrd Critical Dry Spell			Longest duration of CDS
		Start mean date	End Mean Date	Duration	Start Mean Date	End Mean Date	Duration	Start Mean Date	End Mean Date	duration	
	1	2	3		4	5		6	7		8
1	Mau	17 July	3 Aug	18	12 Aug	23 Aug	11	5 Sep	21 Sep	17	45 (1983)
2	Karwi	18 July	2 Aug	16	9 Aug	26 Aug	18	-	-		28 (2002)
3	Satna	22 July	4 Aug	17	4 Aug	19 Aug	16	27 Aug	7 Sep	11	26 (1974)

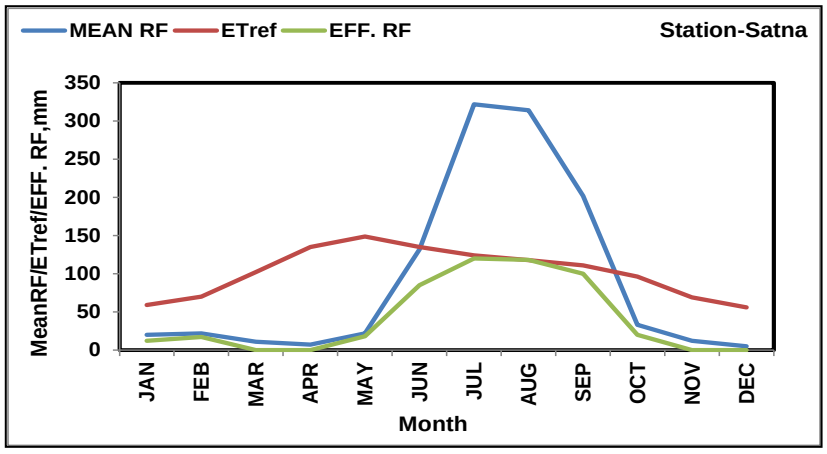


Fig: Distribution of monthly rainfall and Evapotranspiration

Table :Estimation of Crop Water Requirement

S. No.	Name of crop	Crop duration	Sowing time	Total Crop Water requirement (mm)
	1	2	3	4
1	Paddy (Kharif)	97 days	1-Jul	487
2	Soybean (Kharif)	110 days	30-Jun	411
3	Maize (Kharif)	110days	1-Jul	348
4	Wheat (Rabi)	120days	5-Nov	342

j) Proposed work plan for remaining part of the year 2013-14

- Assessment of life saving supplemental irrigation requirement for crops to meet dryspell demand (it is done).
- Classification of zones vulnerable to drought and water scarcity (preparation of vulnerability maps and their physical verification with ground truth).
- Assessment of surface water (Stream flow & Storages) and groundwater availability, (recharge/aquifer storages) at monthly time step.
- Assessment of water demand for domestic, industry and agriculture at monthly time step.

k) List of deliverables (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users interaction workshops)

- This study will yield suitable approach to quantify drought attributes, area specific assessment of water availability, demand and magnitude of deficit.
- Two training courses each for one week duration will be organized to disseminate the knowledge and output of the study during 2013-14 and 2014-15.

5. PROJECT REFERENCE CODE: NIH/SWD/NIH/12-15

a) Title of the study: **Sedimentation Studies for Pong Reservoir, Himachal Pradesh**

b) Study group: A. R. Senthil kumar Sc D & P.I., SWH Div.
Manohar Arora, Sc C, SWH Div.
Suhas D Khobragade, Sc D, HID
Avinash Agarwal, Sc F, SWH Div.
Sanjay K. Jain, Sc F, WRS Div.

c) Type of study: Internal

d) Date of start: 1 April 2012

e) Scheduled date of completion: March 31, 2015

f) Study objectives:

i) To develop a sediment yield model for the catchment area
ii) To generate rainfall and runoff series for the future periods
iii) To compute the sediment yield based on the generated rainfall and runoff series
iv) To predict elevation-area-capacity curve

g) Brief methodology:

Sediment yield model

Multiple Linear regression (MLR) and ANN models are developed to simulate the sediment yield for the catchment of Beas river up to Pong reservoir based on the historical data of rainfall, runoff and sediment yield

Generation of rainfall and runoff series

The data of rainfall and runoff for future 25, 50, 75 and 100 years are generated by the time series modelling with available data of rainfall and runoff series.

Computation of sediment yield and consolidated sediment volume

The developed sediment yield model is applied to compute the sediment volume for future 25, 50, 75 and 100 years. The unit weight of deposited sediment in the reservoir is computed from particle size distribution of suspended sediment concentration, hydrographic survey and porosity of uniformly distributed sediment in the reservoir. The consolidated unit weights of the sediment are arrived at by empirical equation as well as statistical methods. The consolidated unit weights computed by different methods are used to compute the possible range of sediment volume expected to be deposited in the reservoir for the future 25, 50, 75 and 100 years.

Revision of elevation-area-capacity table

The computed sediment volume for future periods is distributed in the reservoir by empirical area reduction method.

h) Results achieved with progress/present status

The monthly rainfall at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam and monthly flow volume and sediment yield at Jwala Mukhi from 1987 to 2009 are used to develop ANN model to simulate the sediment load. The feed forward ANN is trained with input vector selected from the data as mentioned above. The monthly data from 1987 to 2007 are considered for the training of the model and data from 2008 to 2009 are considered for the validation of the model. The ANN model with input vector of flowvol(t), raindehra(t), rainhari(t), rainnangch(t), rainpondam(t) and the structure of 5-2-1 is the best model among the all. The monthly rainfall at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam and monthly flow volume at Jwala Mukhi for future 25, 50, 75 and 100 years are generated by using time series modelling. The best ANN model is used to simulate the sediment load for future 25, 50, 75 and 100 years using the generated series of rainfall and flow volume. The uncertainty analysis of generated data series of rainfall at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam, flow volume at Jwala Mukhi for future 25, 50, 75 and 100 years is carried out. The uncertainty in the generated data series is determined by finding bandwidth of maximum and minimum values with mean values of a particular series. The 1000 ensembles of rainfall at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam, flow volume at Jwala Mukhi for 25, 50, 75 and 100 years are generated by changing the seed of uniformly distributed random number. The dependability of the generated series of rainfall and flow volume is found from the ensembles of the series. This will address the uncertainty in the generated data. The uncertainty in the model is addressed by developing ANN ensembles by boots trap method. Boots trap runs will be carried out with the dependable values of generated series of rainfall and flow volume for future 25, 50, 75 and 100 years to find the dependable sediment yield. The dependable sediment yield will be used for the revision of elevation-area-capacity table for the reservoirs.

i) Expected date of completion: 31 March 2015

6. PROJECT REFERENCE CODE: NIH/SWD/NIH/13-14

a) Title of the Project: **Development of Real Time Flood Forecasting for downstream of Hirakud dam**

b) Study Group: A.K. Lohani, Sc. 'F' & PI, SWH Div.

c) Type of study: Internal

d) Date of Start: April 1, 2013

e) Scheduled date of completion: March 31,.2014

f) Study Area:

The river Mahanadi is an interstate river originating from Chhatisgarh and reaches Bay of Bengal travelling 851 km. More than 99% of its catchment lies in these two states. The basin is basically divided into 3 parts. The upstream catchment (Catchment area=83500sq.km.) covers mostly hilly region of Chhatisgarh. The second middle catchment (Catchment area = 48535 sq.km.) covers the area downstream of Hirakud and before delta. The third part is the flood prone part of delta (Catchment area=9034sq.km, including Chilika lake). The drainage capacity of deltaic rivers is up to 10 lakh cusecs (Patri, 2008). So a discharge of above 10 lakh cusecs can create flood havoc.

g) Objectives:

(i) To collect and process hydrological time series data
(ii) To develop flood forecasting models using conventional and soft computing techniques
(iii) To compare different flood forecasting models

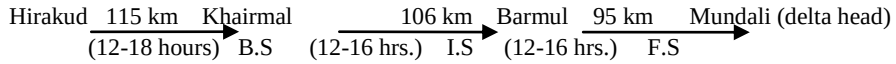
h) Statement of the problem:

Floods are among one of the most destructive acts of nature. Worldwide flood damages to agriculture, house and public utilities amount to enormous amount in addition to loss of precious human and cattle lives. Flood forecasting is used to provide warning to people residing in flood plains and can alleviate a lot of distress and damage. Flood forecasting is an important non structural solution for reducing floods damages and is used to provide warning to people residing in flood plains. Conventional methods of flood forecasting are based on either simple empirical black box which do not try to mimic the physical processes involved or uses complex models which aim to recreate the physical processes and the concept about the behaviour of a basin in complex mathematical expressions. A real time flood forecasting system may provide discharge and water level information at the forecasting site with increased accuracy and lead time.

i) Analysis and Results:

Hirakud reservoir having a catchment of 83400 sq.km. The downstream catchment has three main tributaries like Jeera, Ong and Tel with catchments 2383, 5128 and 25045 sq.km. respectively. So the contributions from the Tel catchment always remain predominant. Even the flood of 2008 is mainly due to the contribution of this tributary. It has produced a peak discharge of 33762 cumecs during 2008. So establishment of a flood forecasting model below the joining of these tributaries reduces the ambiguity. The river Tel joins at Patharla to the main river Mahanadi and our base station Khairmal is at

downstream of Patharla station. The other tributaries Ong and Jeera join also at the upstream of base station (Khairmal). The whole river from Khairmal is taken as one unit ignoring the contribution of further small tributaries. schematic presentation shows the distance and travel time from Hirakud to Mundali presently being used for the official purposes of Department of Water Resources, Government of Orissa.



The selection of an appropriate flood forecasting model depends on the availability of the data, output desired etc. On the basis of the analytical approach for the development of flood forecasting method for the present study is classified as: (i) Methods based on statistical approach, (ii) ANN Approach and (iii) Clustering Approach.

j) Action Plan:

Task	**Apr. -June. 2013**	**July. 2013-Sept. 2013**	**Oct. -Dec. 2013**	**Jan. 2014 Mar. 2014**	**Status**
Data Collection & Processing					Data Collection partially completed
Development of Rainfall-Runoff Model					Developed rainfall- runoff model
Development of Flood Forecasting model					In progress
Development of Real time flood forecasting model					

k) Deliverables:

Real Time flood forecasting system Methodology, Reports and research papers

7. PROJECT REFERENCE CODE: NIH/SWD/NIH/13-15

a) Title of the Project: **Application of DSS(P) for Integrated Water Resources Development and Management**

b) Study Group: A.K. Lohani, Sc. 'F' & PI, SWH Div.
Surjeet Singh, Sc 'D' & Co-PI, GWH Div.
Rahul Jaiswal, Sc. 'C' & Co-PI R. C. Bhopal

c) Type of study: Internal

d) Date of Start: April 1, 2013

e) Scheduled date of completion: March 31,.2015

f) Study Area:

Not yet finalized.

g) Objectives:

(i) To collect and process hydrological time series data and spatial data
(ii) To carry out rainfall-runoff modelling using NAM
(iii) To implement Mike basin in the study area
(iv) To generate scenarios for integrated water resources management

h) Statement of the problem:

The management of water resources requires integration of large volumes of disparate information from diverse sources. An efficient and easy to use framework is required to couple this information with hydrological modelling tools for assessment and evaluation that allow broad, interactive participation in water resources planning and decision making process and effective methods of communicating results to a broader audience. Better and useful information needs to be made available to a larger number of participants in more open and participatory decision making and this information is to be effectively integrated into decision making processes. It is a challenge to integrate new information technologies with traditional methods of analysis and to put these tools to work in practice. A Decision Support System (DSS) helps in attaining this objective. DSS (planning) developed under Hydrology Project-II pertains to a decision support system for integrated water resources development and management. The proposed study will demonstrate the implementation steps and applicability of the DSS(P) for a selected basin.

i) Action plan:

Task	Apr. - Sep. 2013	Oct.-Mar. 2013	Apr.-Sep. 2014	Oct. 2013-Mar. 2014	Status
Identification of the study basin					Identifying the basin in consultation with Chhattisgarh WRD

Data Collection & Processing					
Rainfall-Runoff Modelling using NAM					
Implementation of Mike Basin					
Scenario generation using DSS(P)					

j) Role and Responsibility of Team Members:

Dr. A.K. Lohani: Data Collection, Data Processing, Data Analysis, Simulation, Interpretation of results etc.

Dr. Surjeet: Data Collection, Data Processing, Simulation

Rahul Jaiswal: Data Collection, Data Processing, Simulation

k) Deliverables:

Reports and research papers

8. PROJECT REFERENCE CODE: NIH/SWD/NIH/13-14

a) Title of the study: **Status Report on Soil Erosion and Sediment Transport Modelling**

b) Study group: J.V. Tyagi, Sc F, SWH Div.

c) Type of study: Internal

d) Date of start: April 2013

e) Scheduled date of completion: March, 2014

f) Objectives of the study:

To prepare a state-of-the-art report on soil erosion and sediment transport modeling.

g) Statement of the problems:

The National Water Mission document of National Action Plan on Climate Change (NAPCC) has identified various goals. The document also suggested various strategies for achieving these goals. The suggested strategies include "Research and studies on all aspects related to impact of climate change on water resources including quality aspects of water resources with active collaboration of all research organizations working in the area of climate change". One of the action points for R&D studies highlights the need of "Building a Universal Soil Loss model depicting erosion and sediment transport etc., proving the model based on sediment flow and reservoir sedimentation data, actuating the above model for changed rainfall regime and changed management practices". As a first step, the action plan of the activity module I.5 envisages preparation of a state-of-the-art report on soil erosion and sediment transport modeling and the work is entrusted to NIH. Accordingly, preparation of state-of-the-art report has been taken up.

h) Proposed methodology:

Proposed work plan for the study consists of the following steps.

- Collection of literature from web resources, academic and R&D institutions on soil erosion and transport modeling.
- Thorough review of the collected literature and analysis of various methodologies.
- Compilation of the literature and preparation of the state-of-the-art report.

i) Time schedule:

Work plan	Time Schedule
Collection of literature from web resources, academic and R&D institutions on soil erosion and transport modeling	April - Sept, 2013
Thorough review of the collected literature and analysis of various methodologies	Oct. – Dec. 2013
Compilation of the literature and preparation of the state-of-the-art report	Jan. – March 2014

j) Progress/ present status of the study

The literature on soil erosion and sediment transport modeling is collected from various sources and is under review. Collection of some more literature is in progress. The report will be submitted as per schedule.

k) Adopters of the study:

CWC, NIH, academic and other R&D institutes involved in implementation of the National Action Plan on Climate Change (NAPCC).

l) Deliverables

(i) State-of-the-art report on soil erosion and sediment transport modeling.

(ii) The report would compile various approaches and methodologies for estimating of soil erosion and sediment transport from river basins.

m) Major items of equipment procured: Nil

n) Lab facilities during the study: Nil.

9. PROJECT REFERENCE CODE: NIH/SWD/NIH/13-16

a) Title of the study: **Quantitative assessment of uncertainties in river discharge estimation**

b) Study group: Sanjay Kumar, Sc 'D' & PI, SWH Div.
Sharad Jain, Sc 'F' & Co-PI, WRS Div.

c) Type of study: Internal

d) Date of start: April 2013

e) Scheduled date of completion: March, 2016

f) Objectives of the study:

The objectives of the study are:

1. To estimate uncertainty in river discharge observations.
2. To estimate uncertainty in the stage-discharge (rating) relationship.
3. To estimate uncertainty in stage- discharge relationship using slope as a parameter (back water effects).

g) Statement of the problems:

The uncertainty in the river discharge measurement and estimation is caused by different sources of errors. These mainly includes uncertainty in (a) observations of river stage and discharge used to parameterize the rating curve, (b) presence of unsteady flow conditions, and (c) interpolation and extrapolation errors of the rating curves. The study will provide a framework for analyzing and quantifying the uncertainty in the (i) river flow data (ii) stage-discharge relationship and (iii) stage-slope-discharge relations (for backwater effects) based on the ISO documents GUM (Guides to the expression of Uncertainty in Measurement), HUG (Hydrometric Uncertainty Guidance), ISO 773, 5168, 7066 and 768. The study will also examine various hydraulic factors controlling the flow at a cross section in the river and provides an understanding of independent variables that describes relations among stage, discharge and other parameters specifically discharge measurement under back water effects.

h) Proposed methodology:

Statistical methods/tools and the procedures described in various ISO documents (GUM, HUG) will be used for the estimation of river discharge uncertainties. The uncertainty in discharge measurement (assuming velocity area method) will be quantified as per the ISO 748 which provides the magnitude of these errors at 95% confidence level. The GUM defines the law of propagation of errors for combining uncertainties from several sources and HUG described it for different types of mathematical expressions generally used in hydrometry. This is illustrated by considering the quantity Q as a function of several measured quantities x, y, z . The error δQ in Q due to errors δx, δy, δz…. in x, y, z…., respectively, is given by

$$\delta Q = \frac{\partial Q}{\partial x}\delta x + \frac{\partial Q}{\partial y}\delta y + \frac{\partial Q}{\partial z}\delta z + \cdots$$

The uncertainty of a discharge measurement determined from a stage-fall-discharge rating function (as opposed to a gauged discharge which is determined from a current meter) shall be evaluated using statistical equations based on law of propagation of errors described above. Let X_{rd} be the uncertainty in the recorded discharge, the above error equation is then modified for uncertainty in discharge computation using stage-fall-discharge relationship as

$$X_{rd}=\pm(X_{\alpha}{}^{2} + \beta^{2}X^{2} h_{u/s\text{-}h0} + \gamma^{2}X^{2}{}_{hu/s\text{-}hd/s})^{1/2}$$

In practice, X_{α} is the standard error of the mean relation ($S_{mr)}$. $Xh_{u/s\text{-}h0}$ is the standard error of upstream gauge and $X_{h\ u/s\text{-}h\ d/s}$ is the standard error of fall between the u/s and d/s gauges.

i) Progres:

As required by ISO/BIS the NWIP and the working draft of the ISO 9123 (for the third objective) with updated uncertainty clause has been submitted to ISO for consideration.

j) Data requirements:

Stage and discharge data. Possible sources would be from literature, ISO documents, field organization.

k) Action plan and Time line:

S.N.	Major Activities	1st Year		2nd Year		3rd Year	
1	Literature review including related various ISO standards						
2	Estimation of uncertainty in river discharge measurements (Interim Report-1)						
3	Estimation of uncertainty in stage-discharge (rating) relationship. (Interim Report-2)						
4	Estimation of uncertainty in stage-discharge (rating) relationship using slope as a parameter (back water effects) (Interim Report-3)						
5	Preparation of final report						

l) End users/beneficiaries of the study: Academicians, state and central government departments BIS, ISO.

m) Deliverables: Research papers, reports

10. PROJECT REFERENCE CODE: NIH/SWD/NIH/13-14

a) Title of the study: Suspended Sediment Flux Modelling in the largest sub-basin of Brahmaputra

b) Study group: Archana Sarkar, Sc C, SWH Div.
Rakesh Kumar, Sc F & Head, SWH Div.

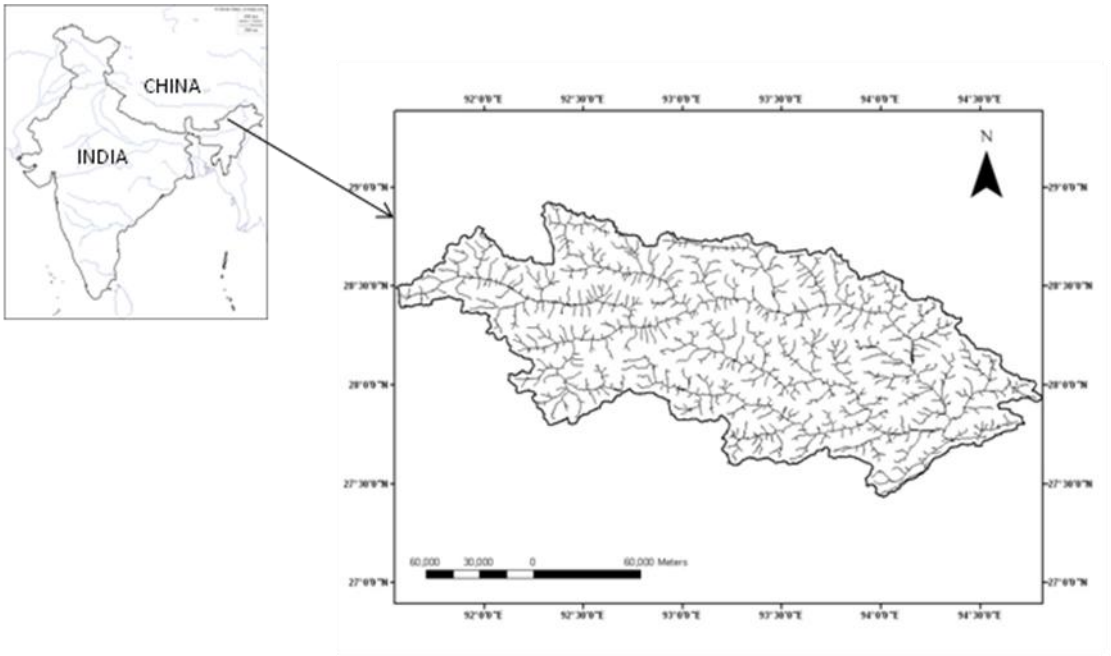
c) Type of study: Internal

d) Date of start: 1 April 2013

e) Scheduled date of completion: 31 March, 2014

f) Study area/Location map

The Subansiri River is the biggest north bank tributary of river Brahmaputra in India. It originates in Tibet beyond the Great Himalayan Range at an altitude of around 5340 m and joins the Brahmaputra in the plains of Assam State in India. The Subansiri River contributes about 10.7% of the total discharge of the river Brahmaputra at Pandu near Guwahati in India. The catchment area of Subansiri basin up to the outlet at Chouldhuaghat is approximately 26,419km^2 from SRTM data, of which about 10,237 km^2 (38.75%) lies in Tibet and the remaining 61.25% in India. The Sub-Himalayan range of Subansiri generally consists of soft sandstones and weathered rocks. During the period of May to October, the intensity of precipitation is high and sediment deposits at areas nearer to and along the foot hills are easily eroded. The study area is given as follows:



g) Objectives of the study:

i. Development of artificial neural network (ANN) based sediment flux simulation models for the Subansiri basin up to Chouldhuaghat gauging site on daily, ten-daily and monthly scales

ii. Development of conventional sediment rating curves (SRC) and multiple linear regression models (MLR) for sediment flux simulation with data similar to ANN models.

iii. Intercomparison of developed models

iv. Study of the effect of type of input data, length of input data, lagging of input data and scale of input data on the accuracy of sediment flux estimation in a large Himalayan River basin and also provides guidance on the types of tasks for which different types of input data may be preferable

h) Statement of the problems:

- "Hydrological modeling studies in Brahmaputra basin" is one of the thrust areas of "12th Five Year Plan"
- Rigorous assessment of sediment fluxes in rivers is required in a wide spectrum of problems such as design of reservoirs and dams; hydroelectric power generation and water supply; water quality and pollution and environmental impact assessment. The Subansiri River promises stupendous hydropower potential (22 projects having potential of 15,191 MW already proposed/in progress) for the country, therefore, accurate assessment of sediment flux is of prime importance.

i) Approved action plan and time line:

Work Plan	**Time Schedule**
Data processing	April - June, 2013
Identification of ANN model architecture and preparation of input files	July – Sept. 2013
ANN model runs, development of SRC and MLR models	Oct. – Dec. 2013
Interpretation of results, inter-comparison of models and preparation of report	Jan. – March 2014

j) Progress

Objectives	**Achievements**
April 2013- Sept 2013	
Data processing	Completed
Identification of ANN model architecture and preparation of input files	Completed

k) Analysis and results:

Data Used

- Daily data of rainfall, rainfall intensity, temperature, snow cover area, discharge and suspended sediment concentration

Data Processing

- Based on the daily data, ten-daily and monthly data series have been prepared for ANN simulation

ANN model identification and input data

- Back propagation feed forward ANN models have been identified for simulation of the suspended sediment flux for the catchment of Subansiri River up to Choudhuaghat gauging site. Input data for ANN models have been prepared using various combinations of the historical data of rainfall, rainfall intensity, temperature, snow cover area, discharge and suspended sediment concentration on daily, ten-daily and monthly basis considering different lag time.

l) End users/beneficiaries of the study

Water Resources Department in particular and people at large in general.

m) Deliverables

i) Best model for simulation of suspended sediment flux in Subansiri basin
ii) Comprehensive report giving data, maps and results
iii) Research papers.

(For Reporting)

Proposed Project : Australia-India -- International Collaboration
Submitted Under: Australia-India Council General Grant Round - June 2013

Project Title: Integrated spatial assessment of vulnerability to drought using geophysical and climatic factors: A framework for drought-risk management in Australia and India

Collaborating Institutions: Two Research Locations (Australia and India as follows):
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1. Australian Centre for Sustainable Catchments, University of Southern Queensland , West Street, Toowoomba, Australia (Administering Organization)
   Name of PI: Australia- **Dr. Ravinesh C Deo, Assoc. Professor**;

2. Headquarters, National Institute of Hydrology at Roorkee, Uttarakhand, India (Partner Organization).
   Name of PI: India - **Dr. R.P. Pandey, Scientist F**; Surface Water Div.

Type of study: Australia-India -- International Collaboration
Likely to be funded by : Australia-India Council

Project Duration: 1-years

Date of start: 01/02/2014

Scheduled Date of Completion: 01/02/2015

Brief Description of the Project:

Australia and India are arid/semi-arid continents. In Australia, agriculture absorbs 60% of water-usage but due to persistent droughts this has reduced from 16,000-GL (2001/2002) to 7,000-GL (2007/2008) within the Murray-Darling Basin. In India, droughts are catastrophic for agriculture, community and productivity. However, recovery is sometimes implemented by ad-hoc, short-term or superficial means. Consequently, preparedness, mitigation and vulnerability and risk-detection efforts are warranted.

The project will develop Drought Vulnerability Indices (DVI) using Geographic Information Systems. The project will employ multiple indicators of physiographic and climatic origin that contribute to the vulnerability to drought. Vulnerability may be related to activities like agriculture, water-use trends, demographic-profiles, socio-economic policies, community response and coping abilities. Thus, a method for spatially representative depiction of vulnerability using multiple indicators will be developed. The indicators may include topographic characteristics, land use types, soil types, relative availability of surface water and groundwater, water demand and utilization and rainfall departures. The integrated weights of these indicators will be over-layed to depict the overall vulnerability to drought.

DVI will be an input parameter for regional downscaling of drought-risks. It may create pathways for policy-experts to project social impacts of drought and advisory bodies to determine the likely future Exceptional Circumstances claims. Major research exercises will

be implemented via teleconferencing, meetings and training workshops. The project is envisaged to impact various streams of inter-governmental response to drought policy. New stakeholder knowledge on relative spatial distributions of low, moderate and high-risk zones will help develop drought policy modelled by productivity commissions.

This project will elucidate new spatial representation of vulnerability to drought within the Murray Darling Basin and Tons Madhya Pradesh (India). A cross-institutional approach is proposed between Dr Rajendra Pandey (National Institute of Hydrology, Government-of-India) and Professor Roger Stone, Dr Ravinesh Deo, A/Professor Armando Apan and Dr Shahbaz Mustaq (Australian Centre for Sustainable Catchments).

OBJECTIVES OF THE PROJECT:

The project will foster mutual sharing of tools, technology and knowledge between the Administering and Partner institutions. Key objectives are:

1. identifying hydro-meteorological indicators of water-scarcity and the relevant physiographic factors that determine vulnerability to drought on regional scales,
2. characterizing environmental, hydrological, social and drought-policy by classifying zones vulnerable to drought,
3. developing approaches with new strategies for consolidating stakeholder knowledge for understanding drought-risks,
4. developing spatio-temporal vulnerability maps to inform drought-risks to the community.

List of deliverables (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users interaction workshops)

This study will yield suitable approach to quantify drought attributes, area specific assessment of risk to drought and adaptation of mitigation measures.

WATER RESOURCES SYSTEM DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. S K Jain	Scientist F & Head
2	Dr. S K Singh	Scientist F
3	Mrs. Deepa Chalisgaonkar	Scientist F
4	Dr. Sanjay K Jain	Scientist F
5	Dr. M K Goel	Scientist F
6	Sri D S Rathore	Scientist F
7	Dr. P K Bhunya	Scientist D
8	Dr. Renoj Thayyen	Scientist D
9	Sri L N Thakural	Scientist B
10	Sri. Manish Nema	Scientist B
11	Sri P K Mishra	Scientist B
12	Sri Tanvear Ahmed	Scientist B
13	Sri P K Agarwal	Scientist B
14	Sri Yatvear Singh	PRA
15	Mrs. Anju Chowdhary	SRA

WORK PROGRAMME FOR THE YEAR 2013-14

S. N.	Title	Study Team	Duration	Funding
Ongoing Internal Studies				
1.	Trend and variability analysis of rainfall and temperature in Himalayan region	L.N.Thakural Sanjay Kumar Sanjay K. Jain Sharad K. Jain Tanvear Ahmed	3 years (10/11-09/14) **Continuing study**	NIH
2.	NIH_Basin A WINDOWS based model for water resources assessment in a river basin	M.K. Goel S.K. Jain D. Chalisgaonkar P.K. Mishra	2 years (4/13-3/15) **Continuing study**	NIH
3.	Impact of climate and landuse change on floods of various return periods	P.K. Bhunya Sanjay Kumar D.S. Rathore	2 years (4/13-3/15) **Continuing study**	NIH
4.	Web GIS based snow cover information system for the Indus basin	D.S. Rathore D. Chalisgaonkar L.N. Thakural T. Ahmed	2 years (4/13-3/15) **Continuing study**	NIH
5.	Assessment of Water Footprint of the National Capital Territory (NCT) of India	D. Chalisgaonkar Sharad K. Jain P.K. Mishra	2 years (4/13-3/15) **Continuing study**	NIH
6.	Assessing climate change impact across KBK region of Odisha	P.K. Mishra Sharad K. Jain Sanjay K. Jain P K Bhunya	2 years (4/13-3/15) **Continuing study**	NIH
7.	Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range	Renoj J Theyyan S P Rai M.K. Goel	4&1/2 years (9/09-3/14) **Continuing study**	NIH
Sponsored Studies				
1.	Glaciological studies of Phuche Glacier, Ladakh Range.	Renoj J Theyyan S P Rai M.K. Goel	5 years (1/10-12/14) **Continuing study**	DST
2.	Preparation of Ganga River Basin Environment Management Plan (GRBEMP)	Dr Sharad K Jain, Dr N C Ghosh, Dr Sanjay K Jain, Dr M K Goel	**Continuing study**	
New Internal Studies				
1.	Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj	Manish K. Nema Sharad K. Jain	**New study**	NIH
2.	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain Sharad K. Jain Renoj J. Theyyan	**New study**	NIH
3.	Present status of water storage and diversions in major rivers in India	P K Agarwal Tanvear Ahmed Sharad K. Jain Sanjay K. Jain M K Goel	**New study**	NIH

ONGOING/ COMPLETED INTERNAL STUDIES

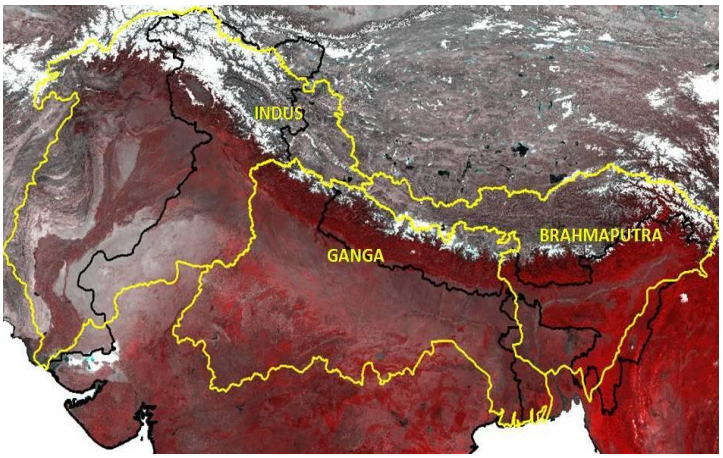
Study 1:

Title: Trend and variability analysis of Rainfall and Temperature in Himalayan region

Study Group	-	Mr. L. N. Thakural, Sc-B, PI Dr. Sanjay Kumar, Sc-E1, Co-PI Dr. Sanjay Kumar Jain, Sc-F, Co-PI Dr. Sharad Kumar Jain, Sc-F, Co-PI Mr. Tanveer Ahmed, PRA, Co-PI
Type of Study	-	Internal
Start Date	-	October 01, 2011
Scheduled date of completion	-	September 30, 2014

Location/Study area

The study is a case study and is a step to understand the behaviour of climate in Himalayan region covering western, central and eastern Himalayas. The Himalayas, which means the storehouse of snow and ice, is the world's youngest, highest, most rugged, sensitive and extensive mountain system having 14 peaks over 8000m and hundreds over 7000m and 530 peaks above 6000m.



Objectives of the study:

The objectives of the study are:

4. To create database for hydrological parameters (Rainfall and Temperature) for the Himalayan region.
5. To estimate temporal and spatial characteristics of the rainfall and temperature time series.
6. To carry out trend and variability analysis of rainfall and temperature.

Statement of the problem:

Interest in climate variations has experienced a significant increase in recent years due to the important economic and social consequences connected with extreme weather events. Most of the studies regarding climate change only seek to detect potential trends or fluctuations in the long term mean of climatic signals, but the study of variability changes and extreme event behaviour is also essential. In the present study statistical analysis, trend and climatic variability changes in climatic variables namely temperature and rainfall will be carried out in Himalayan region, India. The parametric and non-parametric approaches will be used to determine the trends in the time series data of these meteorological parameters

Methodology:

Statistical techniques/tools will be used to evaluate the temporal and spatial characteristics of the rainfall and temperature time series (statistical distribution, temporal correlation, spatial correlations). As meteorological data in the Himalayan region is scarce the rainfall data from APHRODITE would also be used in the study. A comparison of rainfall from APHRODITE with the ground based stations will also be carried out. The trends and variability analysis of rainfall and temperature time series would be evaluated using the following statistical techniques for various time scales.

1. Parametric approach for trend and variability.
2. Mann-Kendall test and Sens's estimator of slope method (non-parametric) for trend and variability.

Approved action plan and timeline:

Sr. No.	Major Activities	1st Year		2nd Year		3rd Year	
1	Literature review						
2	Data collection & preparation for analysis						
3	Temporal and Spatial characteristics of the rainfall and temperature time series and their statistical distribution.						
4	Analysis using parametric approach						
5	Analysis using non-parametric approach						
6	Preparation of report**		Part-1	Part-2		Part-3	

Achievements

Year	Objectives (April-October 2013)	Achievements
2013	Analysis for Eastern	• The hydro meteorological data in the eastern

	Himalayan region	Himalayas has been analyzed for temporal and spatial characteristics. • The parametric approach has been used to find out the trend in temperature and rainfall time series. • The non-parametric approach has been used to detect trends in temperature and rainfall series.

Recommendations / suggestions in previous WG

No specific comments were made during the previous working group.

Analysis and Results

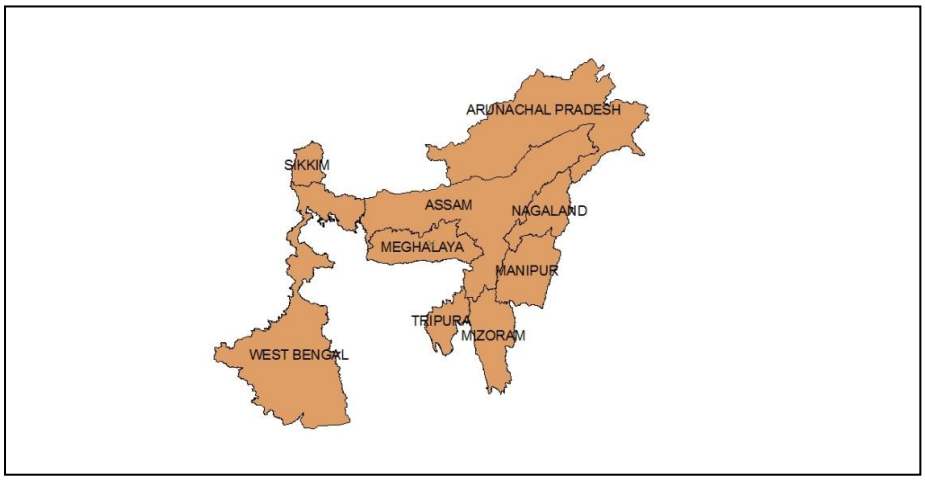


Figure 1: Eastern Himalayan region

The climate of north eastern India varies with elevation. Areas that are at a very high elevation in the Upper Himalaya close to the Tibetan border have an alpine or tundra climate. Below the Upper Himalayas are the Middle Himalayas, where people experience a temperate climate. Areas at the sub-Himalayan generally experience humid, sub-tropical climate with hot summers and mild winters.

The climate change variability and trend of temperature and rainfall in eastern Himalayas have been carried out for the observational sites Cherrapunji, Guwhati, Imphal, Mohan bari, North Lakhimpur, Shillong, Passighat, Ziro, Ture , Kailashahar, Tejpur and Agartala situated at different altitude in the eastern Himalayan region. The parametric (linear regression) and non-parametric (Mann-Kendall test and Sen's estimator of slope) methods have been used to determine the trends in the time series data of meteorological parameters namely temperature and rainfall. On the basis of these methods rising and falling trends in temperature and rainfall at various stations have been analysed.

The trend significance was tested at 95% confidence level. For the analysis of data series changes for different seasons, the year was divided into four principal seasons namely pre-monsoon, monsoon, post monsoon and winter.

Trends in Temperature

The magnitude of the trends in the mean temperature time series on seasonal and annual time scale is determined using the Sen's slope estimator (Table 1). The Man-Kendall test was applied to this time series to ascertain the significance of trends (Table 1).

Table 1: Sen's slope (^{0}C/year) for seasonal and annual mean temperature

Bold indicates statistical significance at 95% confidence level as per with Mann-Kendall test (+ for increasing and – for decreasing)

From the table, it is seen that there is increase in mean temperature almost at all the stations except Tura in the monsoon, post monsoon, winter season and at annual scale. Tura station indicated falling trends in all the seasons with winter showing statistically significant rise. The rising trend at Ziro station during pre monsoon, monsoon, post monsoon season was only statistically significant at 95% confidence. During monsoon, post monsoon and winter seasons, annual two stations (Shilong and kailashahar) experienced rising trend which are statistically significant with time

Stations	PRE MONSOON	MONSOON	POST MONSOON	WINTER	ANNUAL
Passighat	-0.006	0.007	0.025	0.004	0.003
Ziro	**0.017**	**0.016**	**0.012**	0.021	**0.017**
Tura	-0.068	-0.034	-0.012	**-0.054**	-0.046
Cherrapunji	0.003	0.001	**0.005**	-0.001	0.002
Shilong	0.005	**0.001**	**0.016**	**0.01**	**0.007**
Kailashahar	0.013	0.014	**0.027**	**0.028**	**0.018**
Imphal	0.002	0.008	0.008	0.018	**0.023**
Agartala	-0.017	**0.014**	0.018	0.001	0.003

Trends in Rainfall

The magnitude of the trends in the annual mean temperature time series on seasonal and annual time scale is determined using the Sen's slope estimator is given in Table 2. The Man-Kendall test was applied to this time series to ascertain the significance of trends (Table 2).

Table 2: Sen estimator of slope (mm/year) for seasonal and annual temperature.

Stations	PREMONSOON	MONSOON	POSTMONSOON	WINTER	ANNUAL
Ziro	-1.535	0.063	0.386	0.157	-1.75
Cherrapunji	-0.939	-8.878	-0.711	-0.868	-10.4
Shilong	**5.086**	**9.925**	**3.048**	0.566	15.801

Kailashahar	5.33	-3.947	-0.4	0.842	0.583
Imphal	1.678	-3.178	0.692	0.785	-0.075
Agartala	3.6	**-10.08**	-0.812	0.7	-5.918

Bold indicates statistical significance at 95% confidence level as per with Mann-Kendall test (+ for increasing and – for decreasing)

From the table, it is much obvious from Sen's slopes that at most of stations there is a decreasing trend in rainfall. In seasonal data there are no statistically significant trends except at Shilong and Agartala. At Shilong statistically significant positive trends is indicated during Pre-monsoon, Monsoon and post-monsoon seasons. At Agartala there is a negative trend in Monsoon season which indicates a decreasing rainfall at the station.

Adopters of the results of the study

Mountainous basin is highly sensitive to climate change, any change in temperature and rainfall highly influences stream flow downstream. The trend describes the long smooth movement of the variable lasting over the span of observations, ignoring the short term fluctuations. The study is a step to understand the behavior of climate in Himalayan terrain of India which can be utilized for proper planning and management.

Deliverables:

Research papers and reports

Major items of equipments procured: Nil.

Lab facilities used during the study

GIS software, ERDAS Imagine and ARCGIS and Microsoft office.

Data procured and generated during the study:

Rainfall and Temperature data collected from various sources.

- Rainfall data from APHRODITE downloaded (0.5 deg. 1957-2007)
- Ground based observations of temperature and rainfall (North-East, Western Himalayan regions).
- GIS map prepared for the study area.

Study benefits/impacts

The study will evaluate the temporal and spatial characteristics and trends in temperature and rainfall time series in the Himalayan region essential for the assessment of impacts of climate variability and change on the water resources of a region.

Study 2:

Title: NIH_Basin – A WINDOWS based model for water resources assessment in a river basin

Study Group	-	M. K. Goel S. K. Jain Deepa Chalisgaonkar Prabhash K. Mishra
Type of Study	-	Internal
Start Date	-	April 01, 2013
Scheduled date of completion	-	31st March, 2015

Objective of the study:

Envisaged objective of the study is to develop a WINDOWS interface (named as *NIH_Basin* – NIH_Basin-Simulation) of a model developed for assessment of water resources in a river basin for easy application by the user groups. It is also proposed to carry out a number of modifications in the model developed in earlier study for comprehensive analysis of water resources at basin scale.

Proposed Methodology:

A detailed spatially distributed model has been developed at NIH to assess various components of hydrological cycle in a river basin. Various spatial, temporal, and attribute information are utilized by the model to estimate the water availability in the basin; water demands for different uses; and water storage in different hydraulic structures, in soil water zone, and in groundwater aquifer in a river basin. The model can be used to: a) visualize the effect of changes in land use, cropping pattern, climate and population and industrial growth on the basin water resources, and b) analyze various management options like inter-basin transfer of water, development of new water resources projects etc.

The model has large requirements for database development and its applications. Therefore, it is planned to prepare input data files in graphical user-interactive forms for its easier application by other user agency. In addition, some limitations of the current model are planned to be addressed which include: i) specification of EAC tables or corresponding relationships for various storage structures, ii) rule-curve based operation of reservoirs so that different operation policies of the system can be simulated, iii) option of hydropower simulation in the basin, iv) routing of overland and channel flow, and v) simplified representation of groundwater resources.

Progress Achieved

The layout plan of the software for various activities has been prepared as shown if Figure - 1. Four important modules of the software include:

a) Database preparation
b) GIS analysis
c) Model execution
d) Analysis of results

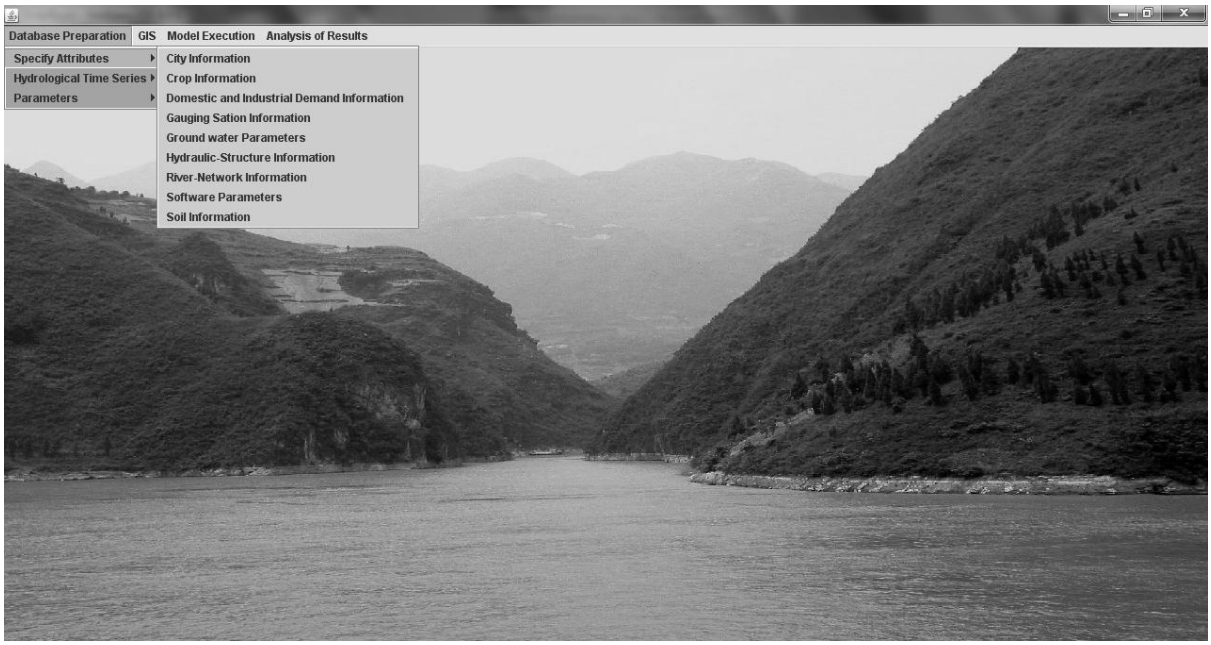


Figure – 1: Layout plan of *NIH_Basin*

The *"Database Preparation"* module is planned to include forms for the entry of attribute and temporal data of hydrological variables and model parameters. One such form for entry of crop details is shown in Figure – 2. In the *"GIS Analysis"* module, it is planned to link the free domain GIS (ILWIS system) for creating and processing geo-spatial data. This module will also contain provisions for converting raster data to ASCII format.

In the *"Model Execution"* module, various sub-models which are run for aggregating spatial information will be provided. In addition, the main *Basin* model will also be provided in this module. In the *"Analysis of Results"* module, provision will be made to view spatial and hydrological results of the model.

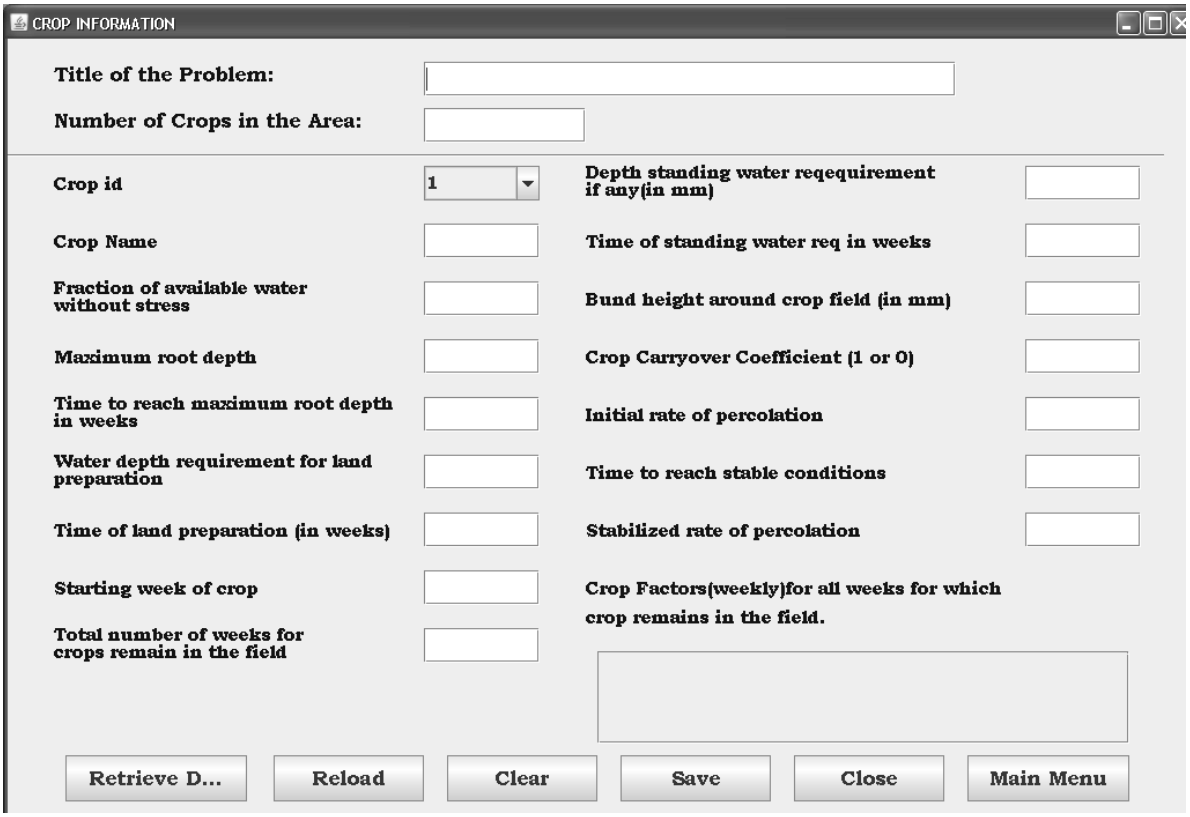


Figure – 2: A sample form for specifying crop attributes

The software is being developed on Java Platform. In the process of model modification, the equations for representation of elevation-area and elevation-capacity curves for various reservoirs in a river basin, as analyzed in the report on *"Mathematical Representation of Elevation-Area-Capacity Curves for Indian Reservoirs"* have been finalized for adoption.

Adopters of study and study benefits/impacts

The study can help water resources departments and river basin authorities in the analysis for river basin planning and management. It can also help in assessing the impact of various natural and anthropogenic activities on various components of the hydrological cycle.

Deliverable

A WINDOWS based model developed at NIH for integrated river basin planning and management.

Study 3:

Title: Impact of Climate and Landuse Change on Floods of Various Return Periods

Study Group: (i) P. K Bhunya, Scientist D,
(ii) Dr. Sanjay Kumar, Scientist D,
(iii) D. S Rathore, Scientist F

Duration: Two years (April 2013-April 2015)

Funding: Internal

Objectives

(i) Compute the climate scenarios using General Circulation Model (GCM) by downscaling it to fit the region. (ii) Impact of weighted climate change scenarios on the return period of flood for one catchment in Mahandi basin. (iii) To examine the statistical trend in 50-y and 500-y return period flood affected by factors such as land use. (iv) Future scenario and uncertainty introduced by increasing the upper and lower bound floods by a certain percent, and check its effect on a in-situ diversion weirs (on a main stream in referred (i) catchment).

Progress

The monthly and annual maximum peak flood series 14 GD sites maintained by CWC (1978-2009) of Mahanadi region has been checked for consistency and missing value records. Average rainfall in two selected IMD stations in Mahanadi basin: (i) Sambalpur (ii) Cuttack has been collected and being tabled separately for Monsoon and Non-monsoon, and also being separately made records for heavy (> 15 cm) and moderate monthly rainfall data. The record so far collected is for the year: 1951-2010. Two small catchments Br-385 (Sandur) and Br-235 (Ranjhor) in Mahanadi basin was taken for getting the stream order and land use landforms using satellite data and corresponding toposheets. A hyposmetric map (RS imagery) was also used for ten catchments in Mahanadi region to show the elevation, making it a topographic map to get a picture of low lying, and higher altitudes in the basin. A published report of WALMI, Cuttack in 2006 was also used to get an idea about the proportion (in %) of major land use type in the Mahanadi basin within Orissa having a catchment area equal to 195256 km^2. The Mann-Whitney test is to be applied to each of the 14 flood gauges independently to get an idea of the optimum year of transition ion regards to flow magnitude variations. Percentage deviations in floods of various return periods for Scenario-1 and Scenario-2 under climate change with AMS of 31 and 32 years was also done for two Bridge catchments i.e. Br-187 and Br-15 (sub zone- 3d) in Mahanadi basin.

Deliverables

Climate is a statistical description of weather conditions and their variations, including both averages and extremes. Although climate forecasts are uncertain and will remain so, partly because of scientific uncertainty but also because many aspects of decisions about action. This study is to assess the uncertainty in impacts of climate change on floods in the Mahanadi region.

Output from the study:

P.K. Bhunya , C S P Ojha, Sharad. K. Jain and A. J. Adeloye. Climate Change Pattern and its Effect on Hydrologic Cycle: A Review. A chapter in book entitled "Sustainable Water Resources Management" to be published by American Society of Civil Engineers (Accepted)

Study 4:

Title of study - **Web GIS based snow cover information system for Indus basin**

Study group - D. S. Rathore, Sc F, PI
Deepa Chalisgaonkar, Sc F, Co-PI
L.N. Thakural, Sc B, Co-PI
Tanvear Ahmad, Sc B, Co-PI

Type of study - Internal

Natural of study - Hydrological information

Date of start - April 01, 2013

Scheduled date of completion - 31st March 2015

Duration of the study - 2 year

Objective:

The objective of the study is to publish snow cover information on web as an OGC web service for Indus basin.

Statement of the problem

Satellite remotely sensed data for surface reflectance are available free of cost over internet. The information may be processed to prepare thematic maps of snow cover and make it available to researchers for their area of interest through web services.

Location map/study area

Indus basin is selected for the study.

Approved action plan and timeline:

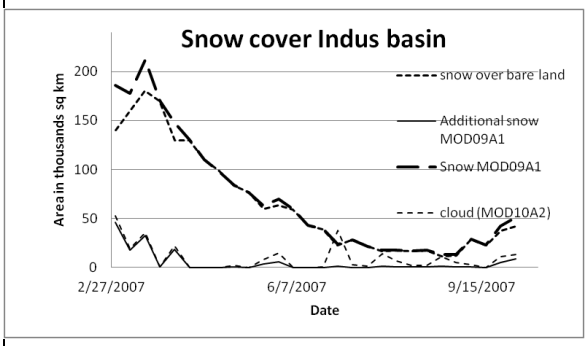
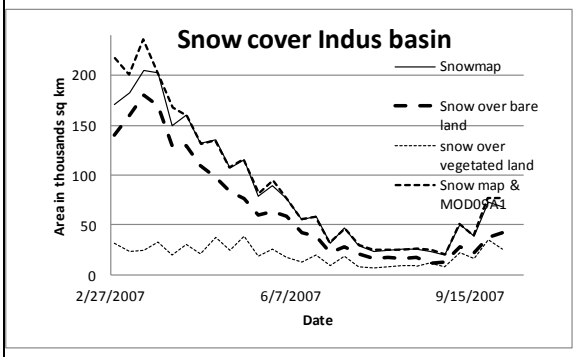
1st quarter	2nd quarter	3rd quarter	4th quarter
Download of data	Processing of the data	Preparation of Web GIS application	Writing of report

Recommendations / suggestions in previous WG

None

Achievements

Year	Objectives	Achievements
2012	To publish snow cover information on web as an OGC web service for	MODIS snow cover maps (Terra and Aqua 8-day composite) and MODIS reflectance (band 1-7) for Terra 8- day composite were downloaded for

	Indus basin	2007. Reflectance data were processed using bands 2, 4 and 6 for snow delineation (snowmap algorithm except snow over vegetation and Temperature threshold). Two snow maps were overlaid (Fig 1, 2).  Fig. 1 Snow in MOD09A1  Fig. 2 Comparing MOD09A1 and MOD10A2

Data procured and generated during the study:

Satellite data downloaded/ available

- MOD10A2, MOY10A2, MOD09A1 (2007)
- Indus basin map

Data generated

Snow cover maps for Indus basin (2007)

Study 5:

Title	-	**Assessment of Water Footprint of the National Capital Territory (NCT) of India**
Study Group	-	D. Chalisgaonkar, Sc-F S. K. Jain, Sc-F Prabhash K. Mishra, Sc-B
Type of Study	-	Internal
Start Date	-	April 01, 2013
Target date of completion	-	31st March, 2015

Background

The water footprint is an indicator of freshwater use that looks not only at direct water use of a consumer or producer, but also at the indirect water use. The water footprint of a product is the volume of freshwater used to produce the product, measured over the full supply chain. With reference to a nation like India, Water footprint assessment aids immensely in analysing and understanding how activities and products relate to water scarcity, pollution and related impacts and what can be done to make sure activities and products do not contribute to unsustainable use of water.

Looking at the increasing skewed supply and demand of the water resources in NCT region of India, this study has been undertaken to make an assessment of the Water Footprint of the NCT region, which may help the decision makers and government bodies in making timely intervention.

Objectives

To get more insight on whether the water scarcity in the NCT region is a manifestation of local consumption or by the increasing industrial demand, the water footprints of the region needs to be assessed with the following major objectives:

- To quantify the different components of water footprint i.e. Blue; Green, & Gray components of the NCT region;
- To assess the international and interstate virtual water flows from and to the NCT region to establish the virtual water balance;
- To analyze past-present-future water footprint of the NCT region for making realistic water management plan;

Work plan:

TASK	**1st six months**		**2nd six months**		**3rd six months**	**4th six months**
Literature review and concepulisation						
Data collection, boundary delineation						

Data analysis and tools development						
Water foot print assessment of NCT, Report writing						

Brief Methodology:
A full water footprint assessment consists of four distinct phases:

1. Setting goals and scope.
2. Water footprint accounting.
3. Water footprint sustainability assessment.
4. Water footprint response formulation.

Progress of the study:
Water footprint assessment for a region requires huge data. Both primary and secondary data from different sources involving line departments are being collected to derive the water footprint. Following are the major data / map which are being collected to accomplish the study.

i. Index map
ii. Area and Population including livestock : Residents, Floating
iii. Crop data : Crop type, Crop production and productivity, Crop evapotranspiration, crop coefficients
iv. Water use data : Domestic, Industrial, Agriculture/ Irrigation, Energy
v. Climatic data : Rainfall, Temperature, Humidity, Sunshine
vi. Commercial Trade data : International and Interstate
vii. Other data : Dilution water requirement, Industrial processes, Pollution, Soil map, Irrigation map, Fertilizer and pesticide use, Water quality standards

It is proposed to calculate the water footprint for the NCT region for the three major sectors viz. agriculture, industry and domestic. The domestic water use in the region is very crucial in view of a large chunk of floating population. Everyday large numbers of people come from the adjoining states for livelihood demanding high domestic water use. We are working on the other two sectors (agriculture and domestic) for which data collection is in progress.

In view of this, at present, our investigation for water footprint assessment is purely done for the domestic water use. In this regards a simple use-friendly calculator has been developed for the NCT region to give the residents an estimate of the water they use on a daily basis. Few snapshots of the calculator are given figure 1, figure 2 and figure 3.

Deliverables:
Research paper and Reports covering Water Footprint for NCT Delhi (Blue, Green and Gray components)

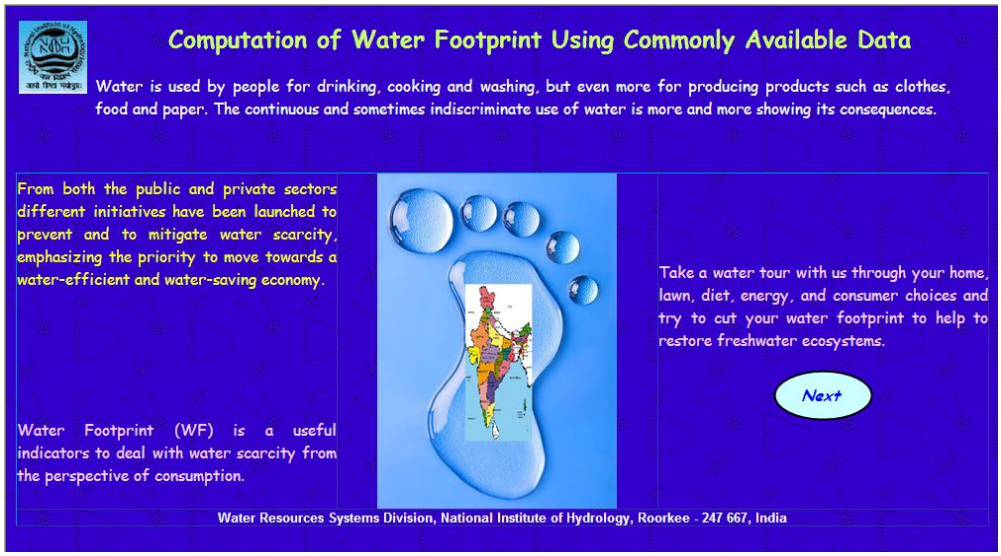


Fig.1: Main screen of the water footprint calculator

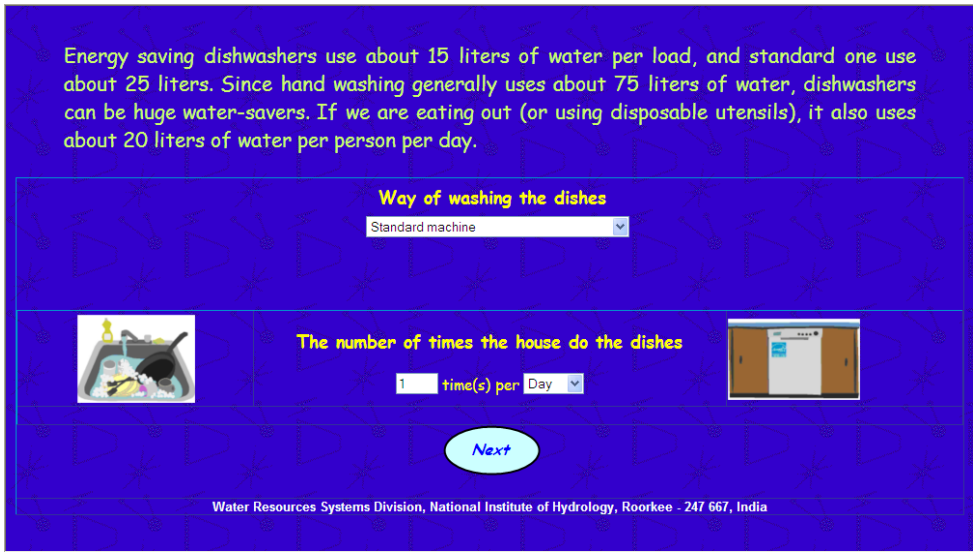


Fig.2: Screen for entering important inputs for the calculator

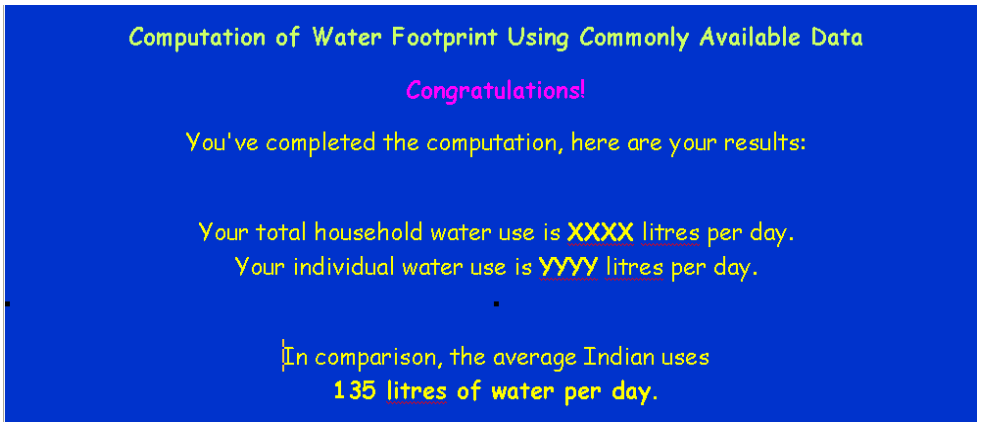


Fig.3: Screen showing the results

Study 6

Title of Study - Assessing Climate Change Impact across KBK (Kalahandi-Bolangir-Koraput) region of Odisha

Study Group - Shri P. K. Mishra , Sc "B"
Dr. Sharad K. Jain, Sc "F"
Dr. Sanjay K. Jain, Sc "F"
Dr. P. K. Bhunya, Sc "D"

Type of Study - Internal
Start Date - April 01, 2013
Proposed date of completion - 31st March, 2015

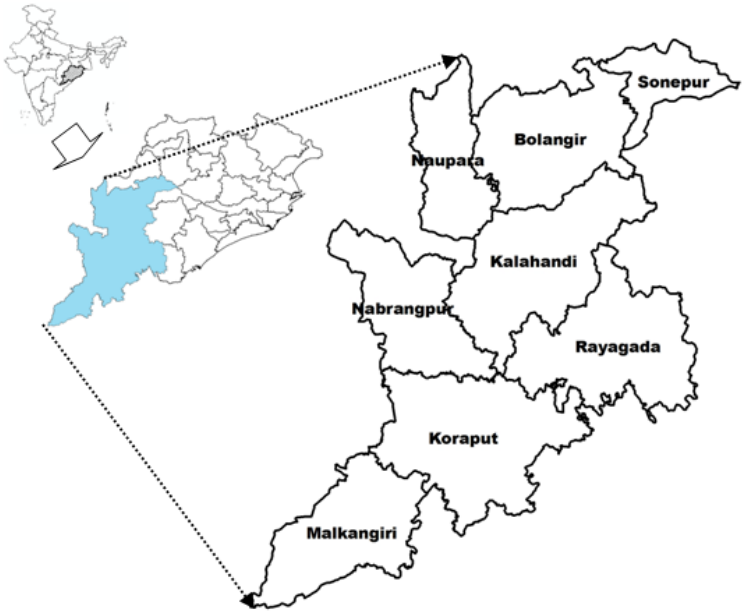
Study objectives:

The proposed study envisages assessing the climate change effects in KBK region, Odisha which is regularly facing drought, water scarcity, and flood as well. The study will focus on the following major objectives:

1. To analyze long-term historical climatic data to determine trend
2. To analyze the future climate in the region based on downscaled GCM data
3. To assess the current potential and utilization gap of water resources in the region to develop management plan

Study area:

The Kalahandi-Koraput-Bolangir (KBK) is three individual district administrations in the state of Odisha. During 1992-93, the three districts were reorganized into eight districts viz. Malkangiri, Nabarangpur, Rayagada, Nuapada, Sonepur, Kalahandi, Koraput and Bolangir. These eight districts comprise of 14 Subdivisions, 37 Tehsils, 80 CD Blocks, 1,437 Gram Panchayats and 12,293 villages. The eight districts which form the KBK region account for 19.72% population occupy over 30.59% geographical area of the State (155820 Km^2). The KBK region is unfortunately famous for every poverty indices set forth by different study groups. The region though witnesses an annual rainfall of 956-1375 mm spread over four monsoon months viz. June, July, August and September, periodically facing drought in every 3-4 years. The climate in the area is sub-humid, dry with extreme summer and winter. The population in the region is a mixed group dominated by tribal. The area is endowed with mineral dominated natural resources and Non-Timber Forest Produce (NTFP) in the large encompasses of forest. Rain-fed agriculture is the principal occupation of the inhabitants. The KBK region in the state of Odisha is shown below:



Approved work plan:

TASK	1st six months		2nd six months		3rd six months	4th six months
Literature review	■					
Data collection	■	■	■			
Data collation, analysis and compilation		■	■	■	■	
Report writing						■

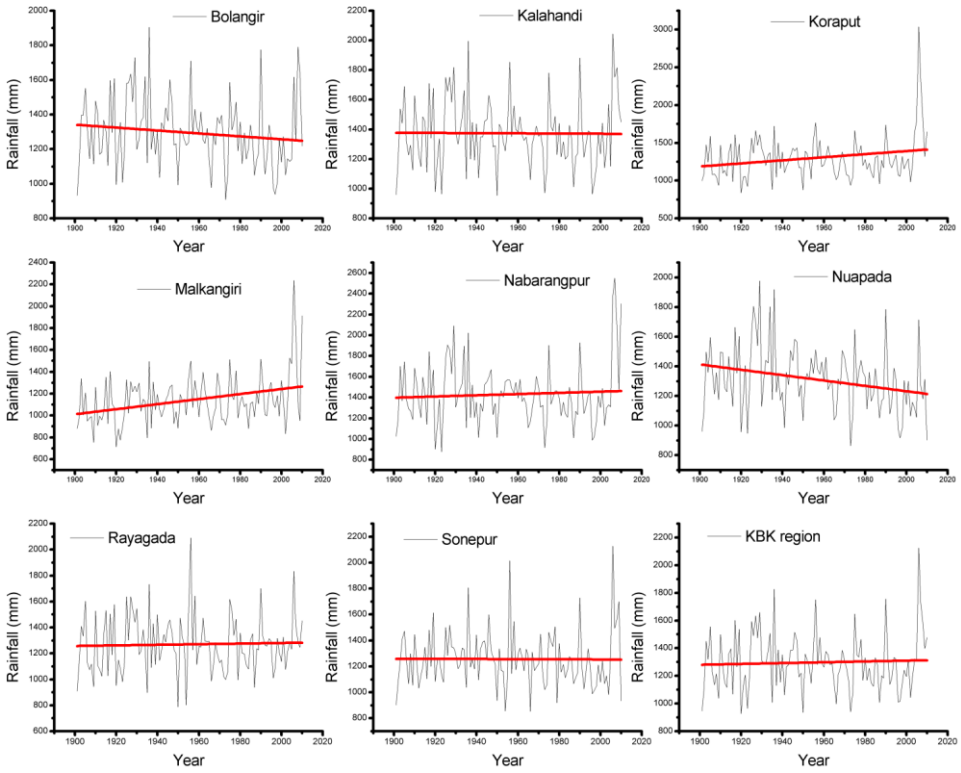
Work Progress:

TASK	WORK PROGRESS
Literature review	√
Data collection	**i. SOI Toposheet (1:250000):** **21 nos.** collected, scanned, geo-referenced, mosaiced, delineated (KBK region) and digitization is under progress to extract themes such as forest, waterbodies, etc. **ii. Soil map (1:250000):** **4 nos.** of sheets collected from NBSS&LUP, Nagpur. All four sheets are scanned, geo-referenced, mosaiced and digitization is under progress. **iii. Climatic data:** Rainfall, Temperature (Min., Max., Avg.) has been collected from India Water Portal ((source: www.indiawaterportal.org) for the period

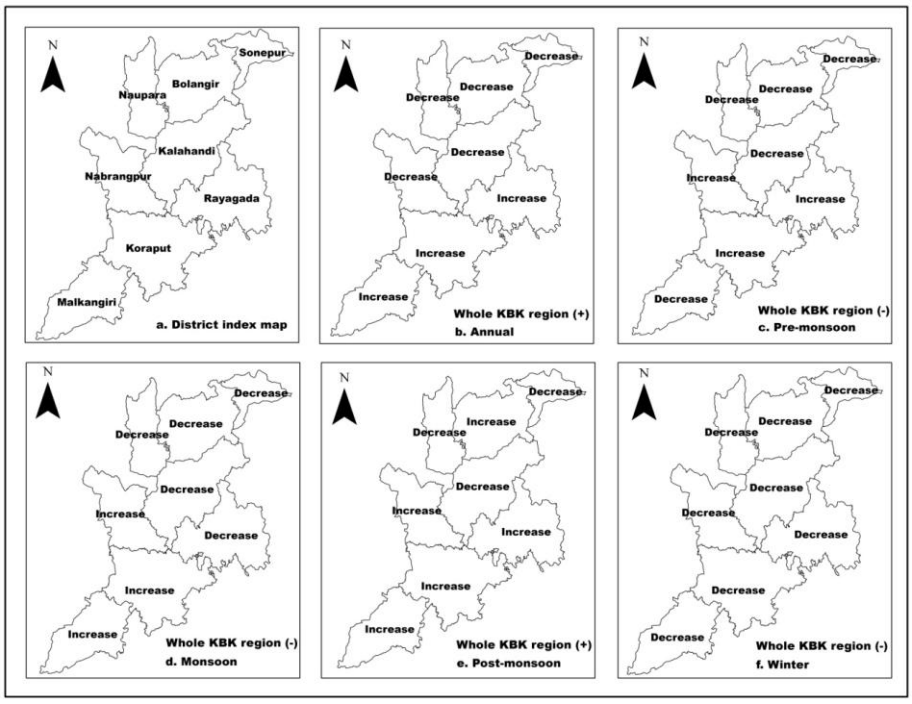
	1901-2010 (110 years) **iv. Hydrological data:** Gauge and discharge data for the 'Tel basin' at one gauging site (Kesinga) has been procured from CWC, GoI for the period 1978-79 to 2008-09 (31 years). Another gauging site (Kantamal) is yet to procure. **v. Landsat imagery:** One set Landsat TM imagery (30m x 30m resolution) has been collected (source: www. http://glovis.usgs.gov/). **vi. ASTER data:** ASTER data set for the region has been procured. DEM and drainage network maps have been generated using the same. **vii. Crop data:** Exploring data collection from Agriculture Dept, GoO, District Agriculture Officers of the concerned KBK districts.
Data collation, analysis and compilation	In pursuance to the proposed 1st objective i.e. to analyze long-term historical climatic data to determine trend), rainfall (110 years) of eight KBK districts has been analyzed to detect the trend using MK test and Sen's Slope Estimate. Shift in the trend has also been performed for the period using Pettitt test and Standard Normal Homogeneity Test (SNHT). The analysis is discussed subsequently. Trend for the Temperature data (Min., Max., and Avg.); Humidity, Reference ET, Discharge is under progress.
Report writing	-
Deliverables (Outcome till date)	A paper has been accepted for presentation in the forthcoming International Conference on AWRDM 2013 jointly organized by Punjab University, Chandigarh and National Institute of Hydrology, Roorkee during 23-27th October, 2013 at Chandigarh.

Major findings of the rainfall trend analysis:

Temporal variation of annual rainfall for the KBK region during 1901 to 2010 with trend lines



Map showing increasing or decreasing trend for the KBK districts



Inferences drawn:

i. Mean annual rainfall 1296.57 mm (Healthy rainfall) with high standard deviation (205.49 mm)
ii. Major rainfall during 'monsoon' followed by 'post-monsoon' and 'pre-monsoon'; Least in 'winter'
iii. Annual rainfall range (Max-Min) = 1195.2 mm
iv. Mean annual rainfall is maximum for Nabarangpur district (1429.31 mm) followed by Kalahandi (1372.93 mm), Nuapada (1312.44 mm) . The least is for Malkangiri (1139.26 mm) district.
v. The annual maximum rainfall event is witnessed in the districts of Koraput (3035.60 mm) and Malkangiri (2236.60 mm).
vi. Linear trend indicates an increasing rainfall trends in the districts of Koraput, Malkangiri & Nabarangpur, decreasing trends in the districts of Bolangir and Nuapada, and the reaming districts (Kalahandi, Nabarangpur, Rayagada and Sonepur) as no trend. Overall, the KBK region is showing increasing rainfall trend in the annual rainfall series.
vii. MK test indicates significant (95% confidence level) increasing annual rainfall in Malkangiri ($z = 2.041$) district and decreasing trend in the Nuapada ($z = -2.221$) district. The whole winter rainfall series is showing decreasing trend (significant in the district of Koraput with $z = -2.203$) which will affect the winter crops grown in the region. The monsoon series in the region is showing a decreasing trend ($z = -0.098$) though non-significant in nature. The districts such as Bolangir, Kalahandi and Nuapada which are already in stress in the water availability especially during summer is indicating a decreasing trend in the rainfall which will further complicates the situation. Although the average annual rainfall is high in these districts, the water scenario is grim. This can be improved undertaking large-scale water conservation activities.
viii. Sen's slope estimate suggests a percentage increase of 0.46% over the last 110 years in the annual rainfall in the entire KBK region.
ix. A close look into the trend shown by different districts, it can be concluded that northern districts (Bolangir, Kalahandi, Nuapada and Sonepur) are showing decreasing trends in the annual rainfall series, whereas southern districts (Malkangiri, Koraput and Rayagada) of the KBK region are showing increasing trends. This may be attributed to the large forest coverage in those parts.
x. Homogeneity tests suggest a shift in the annual rainfall during last decade (during 2000-2005).

Study 7:

a) Title of the Study : ***Glaciological studies of Phuche Glacier, Ladakh Range***.

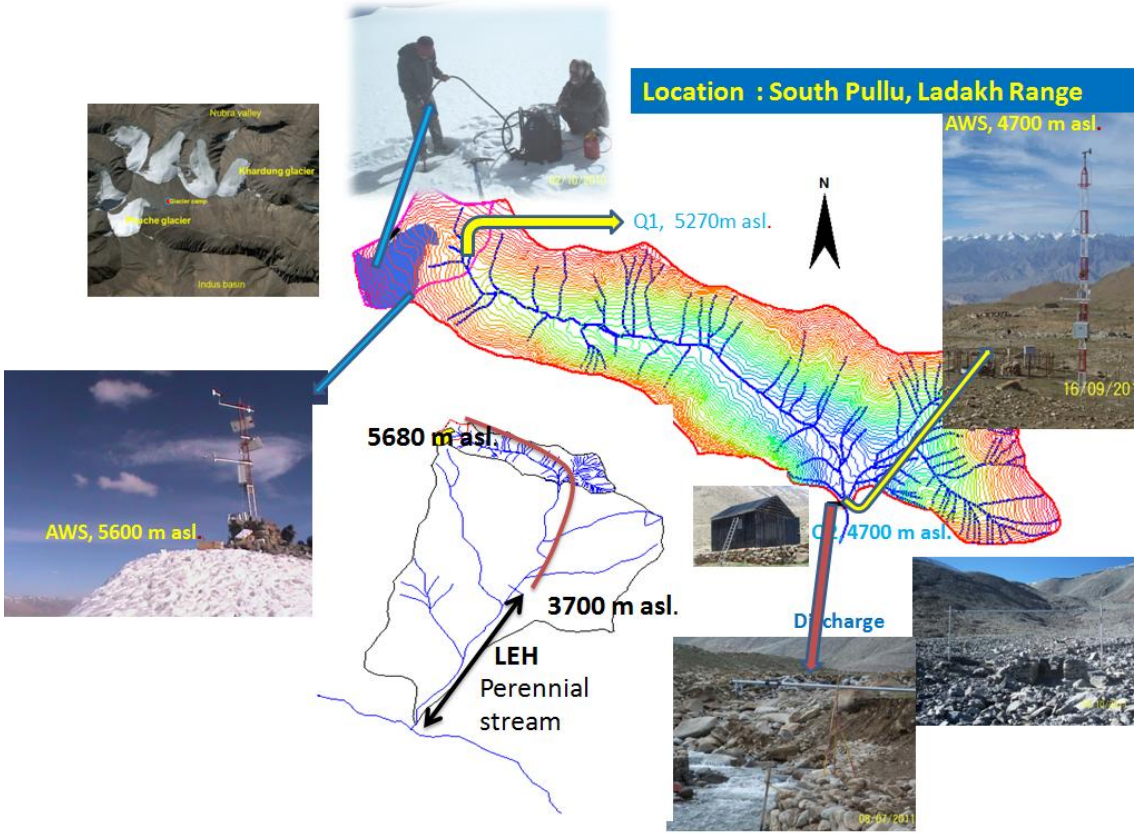
b) Study Group : Dr. R.J Thayyen, Dr.S.P Rai & Dr. M.K Goel

c) Date of Start : 1st January 2010

d) Schedule date of completion: December 2014

e) Type of study : Sponsored Project (DST)

f) Location map / Study area



g) Objectives :

The objectives of the study are as follows:

i. Winter & Summer Mass Balance studies by glaciological method
ii. Runoff measurements
iii. Collection and standardisation of meteorological parameters by AWS
iv. Mass Balance & Runoff modeling
v. To study the composition of stable isotopes $\delta^{18}O/\delta D$ in the winter snow, summer snow/rainfall and separate snow, rain and glacier melt components in the glacier discharge and its temporal and seasonal variations.

h) Statement of the problem:

Response of small glaciers in the Cold-Arid climate system of the Trans-Himalaya to the prevailing climate is not yet known, leading to a huge knowledge gap in our understanding of factors influencing glacier response to the climate change and its consequences. As people fully depend on glacier streams of the region for their sustenance, as the glacier melt feeds into a dry regime, study of these glaciers have greater societal importance.

i) Approved action plan

- Procurement and installation of equipments
- Yearly winter and summer mass balance measurement
- Glacier runoff measurements
- Year round monitoring of meteorological parameters and standardization
- Mass balance & runoff modeling
- Stable isotope characterization of winter snow pack, summer rain/snow and stream flow
- Hydrograph separation by isotope method

j) Achievements

Year	Objectives (for the period April 2013 – September 2013)	Achievements
2013	a) Yearly winter and summer mass balance measurement	Achieved/Under progress
	b) Glacier runoff measurements	Achieved/under progress
	c) Year round monitoring of meteorological parameters and standardization	Achieved/under progress
	d) Mass balance & runoff modeling	Under progress
	e) Stable isotope characterization of winter snow pack, summer rain/snow and stream flow	Achieved/under progress
	f) Hydrograph separation by isotope method	Under progress
	g) vi) Interim-Report writing	Under progress

k) Recommendation / suggestions in previous meetings of Working group / TAC / GB

There were no specific/major recommendations pertaining to the study.

l) Analysis and Results:

Winter and summer mass balance measurements for the years 2009-10, 2010-11 & 2011-12 are successfully achieved. Winter and summer mass balance data for 2012-13 has been collected and the analysis is in progress. Runoff measurement at the glacier catchment outlet is carried out from July to September period every year. Automatic weather station data is being collected from August 2012 onwards and standardization process is in progress.

Samples for stable isotope measurements were collected and the analysis for the year 2010,2011 & 2012 has been completed. Analysis of these data is in progress.

m) Adopters of the results of the study and their feedback

Ladakh Autonomous Hill Development Council (LHADC), Leh

n) Deliverables

Reports and research papers

o) Data generated in the study

Winter & Summer mass balance data, Pro-glacial stream runoff data, Data on various meteorological parameters from 4700m asl. & 5600m asl. Electrical conductivity data of stream discharge, Isoptopic data of stream flow & Snowpack.

Study 8:

a) Title of the Study **:*Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range***

b) Study Group : Dr. R.J Thayyen, Dr.S.P Rai & Dr. M.K Goel

c) Date of Start : September 2009

d) Schedule date of completion: December 2014

e) Type of study : NIH

f) Location map / Study area : Same as above

g) Objectives of the study are:

1. To study climatological and runoff characteristics of a glacier catchment in Ladakh range and modeling of catchment runoff.
2. Study the composition of stable isotopes $\delta^{18}O/\delta D$ in the catchment runoff, winter snow, summer snow/rainfall. Separate glacier melt component from snow, rain, groundwater component of the river flow in the catchment runoff and study its temporal and seasonal variations.

h) Statement of the problem:

Understanding of the cryospheric system processes of cold-arid regions of Ladakh is very poor. Present study is initiated to bridge the knowledge gap of this very important and unique glacier system of the trans-Himalaya. One of the key question is how glacier melt is influencing the catchment runoff in the cold-arid systems? Evaluating the hydrological characteristics of the cold-arid system is also a priority.

i) Approved action plan

- Procurement and installation of equipments
- Catchment runoff measurements
- Year round monitoring of meteorological parameters
- Catchment runoff modeling
- Stable isotope characterization of winter snow, summer rain/snow and stream flow
- Hydrograph separation by isotope method

j) Achievements

Year	**Objectives (for the period April 2013 – September 2013)**	**Achievements**
2013	i. Catchment runoff measurements ii. Year round monitoring of meteorological parameters iii. Catchment runoff modeling	Achieved/Under progress Achieved/under progress Achieved/under progress Achieved/under progress

	iv.	Stable isotope measurement of winter snow, summer rain/snow and stream flow	Under progress
	v.	Hydrograph separation by isotope method	Under progress

k) Recommendation / suggestions in previous meetings of Working group / TAC / GB

There were no specific/major recommendations pertaining to the study.

l) Analysis and Results:

Catchment runoff measurements were carried out for the years 2009-10, 2010-11 & 2011-12. Field data collection for 2013 summer season has been completed. Runoff modeling of 2010 season is completed. Analysis of 2011 discharge data suggests contributions from permafrost melt in the catchment discharge. Higher electrical conductivity of lean flow samples suggests groundwater/permafrost origin. Samples for stable isotope measurements were collected and the analysis for the year 2010, 2011 & 2012 has been completed. Analysis of these data is in progress. Three years of data has given preliminary insight on hydrological characteristics of the cold-arid systems.

m) Adopters of the results of the study and their feedback

Ladakh Autonomous Hill Development Council (LHADC), Leh

n) Deliverables

Reports and research papers

o) Data generated in the study

Catchment runoff data at 4700 m asl. Snow cover depletion curve, snow cover duration at 4700m asl. Electrical conductivity data of stream discharge, Isoptopic data of stream flow at 4700 m asl.

NEW RESEARCH STUDIES

Study 1:

1. Title of the Study: Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj
2. Study Group:

   Principal Investigator: Manish Kumar Nema, Scientist 'B'
   Co-Investigators: Dr. S. K. Jain, Scientist 'F'/ Head, WRSD
3. **Type of Study**: Internal
4. **Date of start:** 01.11.2013
5. **Scheduled date of completion:** 31.10.2016
6. **Duration of the Study:** 3 years
7. **Study Objectives:**
   - To collect/procure/computerize long-term hydrological and climatic data of study area
   - To create an integrated hydrological database of lower Satluj
   - To analyze recorded hydro-climatic data for trends or changes in Punjab Plains of lower Satluj
   - To evaluate monthly/seasonal/annual hydrology of the region
8. **Statement of problem:**

   The most of the hydrologic and climatic datasets varies with time and space. The assessment of trends in climatology and hydrology still is a matter of debate. Capturing typical properties of time series, like trends, is highly relevant for the discussion of potential impacts of global warming or flood / drought occurrences. The majority of the Indian agriculture is dependent on the southwest monsoon, which brings about 80% of the total precipitation over the country which is critical for the availability of freshwater for drinking and irrigation. Changes in climatic variable over the Indian region, particularly the SW monsoon, would have a significant impact on agricultural production, water resources management and overall economy of the country. , A pre-information regarding the changes can be ascertained by the analyzing the trend of these variables. Considering their importance, this study is proposed to understand the variability of the Hydro-climatic variables in Punjab plains of lower Satluj basin by performing standard trend analysis.
9. **End Users / Beneficiaries of the study:** Policy makers, planners, Implementing Agencies/Industries and Government organizations.
10. **Whether study is a new study/extension of previous studies:** New Study
11. **Baseline data/information on the study area and results of previous studies**

    The Punjab plain of lower Satluj basin up to Harike Barrage has been selected for the study in views of its important contribution in agricultural production for the country. The

land surface of Punjab is one of the most fertile plains of India. The Satluj, Ravi and Beas are the major rivers flowing through the Punjab. The Satluj and its tributary Beas enters Punjab near Nangal and Talwara respectively. After moving about 450 km in the plains of Punjab, these two confluence at Harike before crossing over to Pakistan. On micro regional basis the Punjab plains may be divided into the Bari Doab (be-tween the Beas and the Ravi) and the Bist Doab (between the Beas and the Satluj).

12. Methodology

Data Acquisition: All possible hydro-climatic data and other related information shall be acquired, purchased, collected from various state and central agencies mainly includes Indian Meteorology Department (IMD); Central Water Commission (CWC); Bhakra Beas Management Board (BBMB); Ground Water Department, Govt. of Punjab; etc

Processing of Acquired Hydrological data: Integrated hydrological data base will be created in GIS environment after data pre-processing like identification and removal the data gaps, outliers etc.

Linear Regression and Mann–Kendall Test for Trend Analysis: Prior to perfume linear regression test data series shall be standardized by subtracting the mean and diving by their standard deviations. To test for randomness against trend in hydrology and climatology the widely used Kendall's τ statistic will be applied

Magnitude of the Trends: The magnitude of the trend in a time series will be determined using a non-parametric method known as Sen's Slope Estimator.

13. Timeline:

Major Activities	1st year	2nd year	3rd year
Literature survey	■		
Data collection/Monitoring/Field & Lab Investigation	■	■	
Processing of Acquired Hydrological data	■	■	
Linear Regression and Mann–Kendall Test for Trend Analysis		■	
Magnitude of the Trends		■	■
Analysis & Interpretation of data using computer program/model output		■	■
Preparation of Papers/ Report			■

14. Deliverables:

- Papers
- Report

15. Involvement of end users/beneficiaries: Relevant Sectors

16. Specific linkage with Institution and /or other NGOs: None

17. Major items of equipment needed: RS & GIS software

Study 2:

Title of Study - Glacier change and glacier runoff variation in the upper Satluj river basin

Study Group - Dr. Sanjay K. Jain, Sc "F"
Dr. Sharad K. Jain, Sc "F"
Dr. Renoj Theyyan, Sc "D"

Type of Study - Internal
Start Date - November 01, 2013
Proposed date of completion - 31st March, 2016

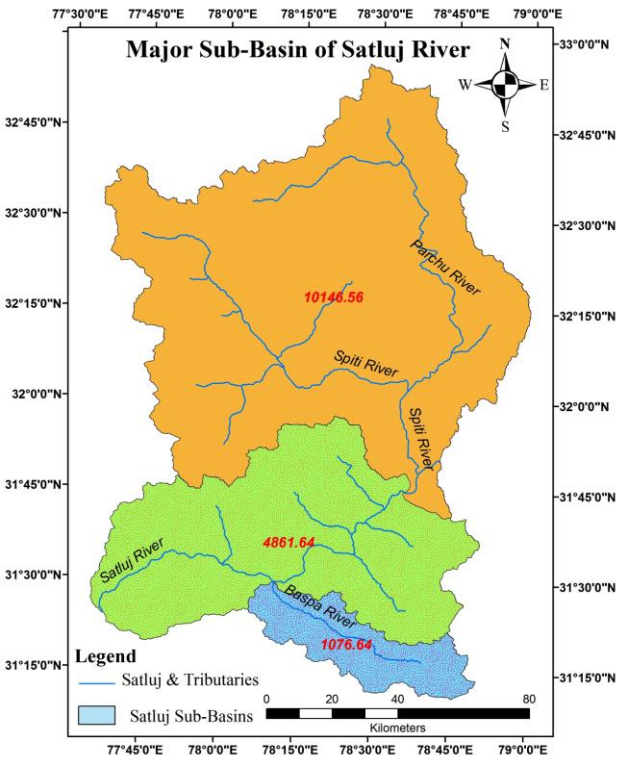
Study objectives:

A major goal of the proposed study is to obtain broader understanding of glacier change (spatial and temporal), reasons and their impact on glacier melt runoff. The objectives of the proposed study are as follows:

- Collection and processing of historical data
- Future climate projections will be applied to see the changes in meteorological variables.
- Assessment of changes in glacier cover area using satellite data
- Modelling of glacier melt runoff.
- Glacier mass balance
- Changes in glacier mass balance will be used to investigate glacier melt contributions.

The Study area

The upper Satluj basin (up to Rampur) will be taken for the present study. The sub basins of the study area will delineated and the two sub-basins i.e. Baspa and Spiti will be studied in detail. The study areas are shown in Figure.



Background of the study:

Glaciers all over the world are expected to continue to retreat due to the global warming throughout the 21st century. Glacier

runoff contributions to streamflow provide critical water supply in many mountainous regions. These glacier runoff contributions are highly sensitive to changes in temperature. Glaciers respond to change in climate in terms of glacier length, mass balance and runoff. The change in glacier cover area results in significant changes to both total annual and summer streamflow downstream. Warmer temperatures cause increased glacial melt but as glaciers recede, their potential contributions to water supplies are also affected. According to the paper published in *Nature Geoscience, 2013*. "Glaciers will retreat but net glacier melt runoff is on a rising limb at least until 2050" in the two watersheds of Himalayan region which were studied. In Western Himalayan basins, several water resources projects are under operation and many more are coming up in near future to harness the available potential. These projects are of paramount importance in terms of drinking water, irrigation, hydropower generation, flood control and subsequent socio-economic development of the region. The availability of stream flow for glacier melt for these projects through out the year is very important.

Keeping in view these facts, the present study has been envisaged to study the stream flow due to climate change and glacier change occurring in the study area.

Brief Methodology:

- Creation of data base of the study area(s)
- Glacier inventory and glacier change occurring in the study area.
- Trend analysis of past and future metrological data
- Glacier mass balance study
- Modelling of glacier melt runoff
- Projection of temperature change
- Assessment of changes in glacier melt runoff vis-à-vis glacier change/change in meteorological inputs

Adopters of the study and study benefits:

The study will be useful for the Bhakra Beas Management Board, Hydropower Agencies and state departments. The study can be utilized by the policy makers associated in the field of water resources.

Deliverables:

The glacier inventory and change in the glacier of the study area. Expected runoff in future and changes in hydropower potential.

Study 3:

Title of Study:	**Present Status of Water Storage & Diversions in major rivers in India**
Study Group:	P. K. Agarwal , Scientist "B" (PI) Dr. Sharad K. Jain, Scientist "F" Dr. Sanjay K. Jain, Scientist "F" Dr. M. K. Goel, Scientist "F" Shri Tanvear Ahmed Scientist "B"
Type of Study:	Internal
Duration:	**Two Years**
Start Date:	October 01, 2013
Proposed date of completion:	September, 30, 2015

Study objectives:

The proposed study will focus on the following major objectives:

4. To prepare the maps of river basins displaying major water storage structures and diversions;
5. To assess the quantum of water storage and diversions in the river basins in India.

Background of the study:

Rivers have served as the lifeline for mankind and continue to do so. Inland water resources of a country can be classified as rivers and canals; reservoirs; tanks & ponds; beels, oxbow lakes, derelict water; and brackish water. Broadly, the rivers of India has been divided in 20 river basins , Out of which the major river basins are: Indus, Ganga & Barahmaputra, Godavari, Krishna, Cauvery, Pennar, Mahanadi, Brahmani & Baitarni, Narmada & Tapi. A number of reservoirs have been constructed in these rivers. There is a lot of surface water potential in these rivers, However, the status of the water storage in these rivers and abstraction of water through Diversion in canals & other means is not available at one place.

In the present study an attempt will be made to prepare the locations/quantity of water storage/abstractions from the major river basins in India, so that a snapshot of water resources development of the whole country is available.

Brief Methodology:

- Preparation of maps of major river basins
- Display of water storage and water diversion locations on the map of the river basins
- Assessment of the quantum of water storage and diversions/abstractions in the river basins in India
- Assessment of water availability/water balance in the river basins.

Adopters of the study and study benefits:

This study can be used by the state irrigation/water resources departments, Hydro-power projects, Hydrologists, policy makers for planning in the field of water resources.

Deliverables: Report; Papers

RESEARCH MANAGEMENT AND OUTREACH DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. V C Goyal	Scientist F & Head
2	Sri Omkar Singh	Scientist E
3	Dr. R V Kale	Scientist B
4	Sri Subhash Kichlu	PRA
5	Sri Rajesh Agarwal	SRA

PROPOSED WORK PROGRAMME FOR THE YEAR 2013-2014

SN	Study	Team	Duration
	Internal Studies		
1	Recession Flow Analysis for Evaluation of Spring Flow in Indian Catchments	Ravindra V Kale (PI) V C Goyal	DOS: Apr 2011 DOC: Dec 2013
2	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs	**Joint study** **NIH HQs:** V C Goyal (Leader) Omkar Singh Ravindra V. Kale **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu RC-Kakinada, RC-Bhopal CFMS-Guwahati, CFMS-Patna	DOS: Apr 2012 DOC: Mar 2015
3.	Action Research for Water Conservation and Management in Selected Village (s) in Haridwar District (Uttarakhand)	Omkar Singh, V.C. Goyal and C.K. Jain	DOS: Apr 2013 DOC: Mar 2015
	Sponsored Studies		
4.	Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India (**New Study**)	**Funded by TIFAC, Government of India under INDIA-IIASA Programme of TIFAC** **NIH** Dr. V. C. Goyal (PI) Dr T Thomas (Co-PI) Dr. R. V. Kale (Co-PI) **Nodal Coordinator :** Dr (Mrs) K Vijaya Lakshmi, DA, New Delhi Dr Sandeep Goyal, MAPCOST, Govt. of MP (India) **International Collaborators:** IIASA, Austria	DOS: Aug 2013-DOC: Jan 2016

Study - 1

1. **Title of the study**:

   Recession Flow Analysis for Evaluation of Spring Flow in Himalayan Region, India (**Continuing Study**)

2. **Name of PI, Co-PI, & their affiliations**

   PI : Dr. R. V. Kale, Sc B, RMOD
   Co-PI : Dr. V. C. Goyal, Sc F and Head, RMOD

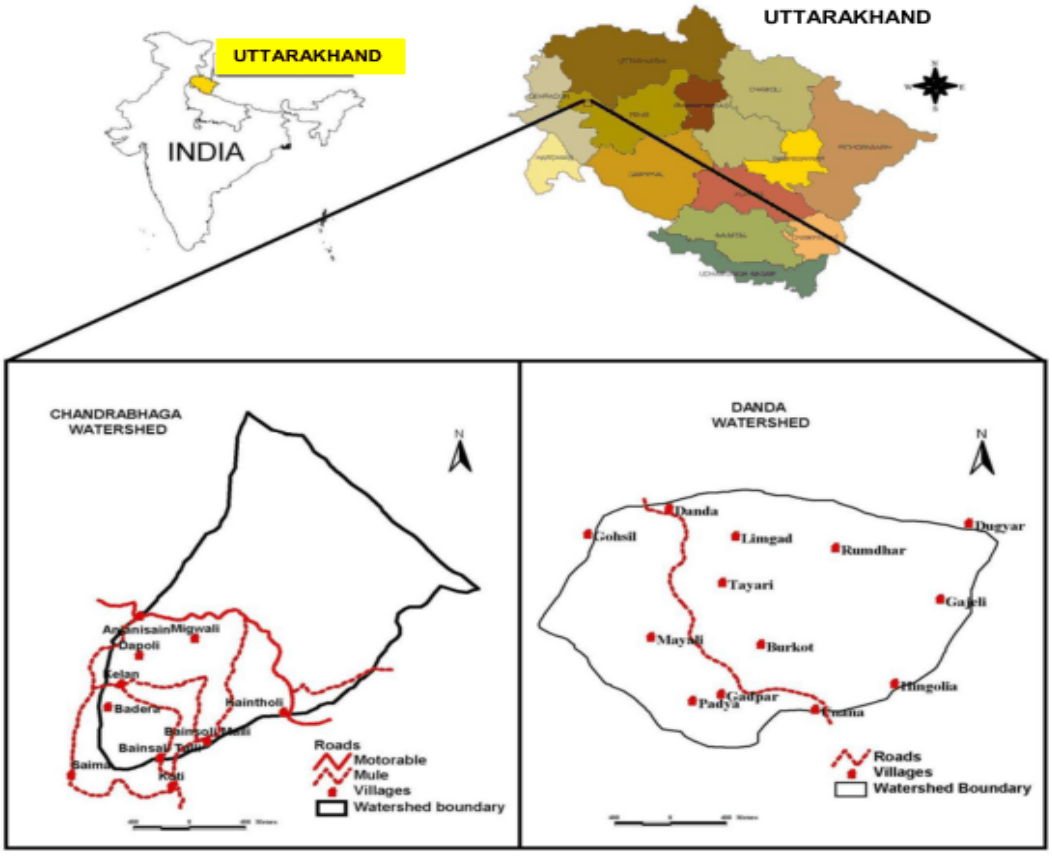
3. **Type of study**

   Internal (NIH funded)

4. **Date of start:** April 2011

5. **Scheduled date of completion:** March 2013

6. **Location map:** The study is being carried out for two small watersheds in the State of Uttarakhand, India. In these Himalayan watersheds number of springs found which are reliable sources of, clean water supply for drinking and domestic use. The geographical location of these watersheds is shown in following map:



7. **Study objectives**

I. To develop a technique to assess the reliability of the spring flow as a sustainable source of drinking and domestic water by analyzing the flow characteristics

II. To assess the potential for springs development as a water source

8. **Statement of the problem**

Springs in the Himalayas, in the Western Ghats and other places in India are the main source of drinking water due to logistical difficulty in creating storage for water. In such areas, majority of spring are of small orders which become dry during summer months. Flow/discharges in such springs vary considerably depending on the catchment characteristics (e.g. area, hydrogeology) and recharge in the catchment. The knowledge about the number of springs as well as their flow characteristics is important in the sustainable development of the water resources of these areas. The study of spring flow analysis has relevance to the water supply to rural areas, specifically hilly areas. As in many locations, rural development agencies would like to develop water resources of the catchment but lack the necessary hydraulic information. Further, the measurement and prediction of spring flows in aquifers are critical to water resources managers to maintain preferred flows based on the effect that current and projected ground water withdrawals have on water levels. Subsequently, the assessment of spring flow using physically based model requires the knowledge of fundamental input parameters such as hydraulic conductivity, specific yield and effective hydraulic conductivity describing the subsurface hydrology which are most problematic to obtain. Since well-drilling to estimate hydraulic parameters is often prohibitively expensive in developing countries, recession flow analysis is a very cost-effective and accurate alternative.

9. **Approved action plan**

Action plan: The collected spring flow and rainfall data will be analyzed for continuity and consistency of the record. In next step, a model will be formulated and will be tested for its accuracy. Then, formulated model will be used for the recession spring flow analysis. The results of the analysis will be produced in the form of research publication, technical report and user manual for field organisations.

Time-line and justification for time over runs:

Period	Task to be completed
April, 2011 – Sep. 2011	Review of literature and collection and preprocessing of data
15th Sep, 2011 – 14th March,	Model formulation

2012	
15th March, 2012 – 15th March, 2013	Data analysis, results preparation and report preparation
April, 2013- December, 2013	Incorporation of topographic module to estimate morphological parameters of the spring watersheds using RS and GIS with hydrological module to arrive at aquifer hydraulic parameters and study report completion. During 37th WG meeting, this objective is undertaken as an extended part of originally decided study. We have received topographical/spatial data in January, 2013 and presently analyzing this data in RS and GIS environment to obtain morphological parameters and use it to estimate spring aquifer parameters. In case of this objective, almost, 60% work is accomplished but due to some unavoidable circumstances there is delay in completion of this work within stipulated time. Further, study on the estimation of Base Flow Index (BFI) for each spring using various methods was undertaken. A new methodology has been developed to estimate BFI for each spring and the results are compared with various available methods. This task is completed. Also, simultaneously, writing of the study report is in progress. Therefore, we expecting another three month extra time to arrive at fruitful results and completion of the report writing.

10. **Objectives vis-à-vis achievements (clearly separate achievements reported in the previous meetings)**

Objectives	**Acheivements**
To develop a technique to assess the reliability of the spring flow as a sustainable source of drinking and domestic water by analyzing the flow characteristics	**<u>Upto March, 2012</u>** • Review of literature was in progress. • Collection and preprocessing of required spring flow data was under progress. • A fully automated objective-based method (adapted matching strip method) for master recession curve

	separation is tested for it accuracy and required modifications are carried out • Recession flow analysis of springs in the Chandrabhaga watershed using above mentioned method was in progress. • Major work on the mentioned objective was in progress
	March, 2012 – Oct., 2012 • Preprocessing of the spring flow data for Danda Watershed was completed. • Recession flow analysis of springs in the Danda watershed using above mentioned method was in progress.
	Oct, 2012 – March, 2013 • Recession flow analysis of the springs in the Chandrabhaga and Danda watershed using fully automated objective-based method (adapted matching strip method) for master recession curve separation, especially estimation of average recession constants of the spring is completed.
	March, 2013 – Sept., 2013 • Estimation of seasonal recession constants (for Rainy, winter and summer season) for all the 30 springs in the Danda watershed and 20 springs in the Chandrabhaga watershed is completed. • Recession constants from all these springs are used to cross verify the optimally separated recession constants for all these springs using fully automated objective-based method (adapted matching strip method) for master recession curve separation. • Statistical analysis of the observed time series datasets of all the springs has been carried out to verify the difference in the behavior of the springs flow. • The work on this objective is

	completed.
To assess the potential for springs development as a water source	• In order to know the base flow contribution as compared to the direct runoff in response to rainfall, Base Flow Index (BFI) for each spring has been developed using Eckhardt recursive digital filter and results are compared with those obtained by using modified recession constant (K) (using adaptive matching strip method for recession curve separation) and $BFI_{\max}$ value (using inverse recursive digital filter) in the Eckhardt recursive digital filter. Further, the results obtained with Eckhardt recursive digital filter and modified Eckhardt recursive digital filter are compared with those obtained using Web based WHAT model, $BFI_{\max}$ optimization available in WHAT model and $BFI_{\max}$ value optimized with Genetical Algorithm (GA). • Using the estimated recession constants for all these springs, prediction of aquifer parameters by using the hybrid model such as topographic module to estimate morphological parameters of the spring watersheds with the help of RS and GIS and hydrological module is under progress and attempt will be made to complete the task before WG meeting. However, if needed, extra 2-3 months time may be required to complete the study including the report writing.

11. Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken

Recommendations/suggestions	**Action taken**
<u>36th WGM</u>	• We are attempting to

Dr. S. K. Bartarya suggested that it would be interesting if recession flow analysis may be made according to control/classification of springs such as Fracture joint or Fluvial related spring etc. (as given in Valdiya & Bartarya, 1991) or on types of aquifer. Further, he also suggested that tracers and isotopes may be incorporated as another tool.	accomplish recession flow analysis according to control/classification of springs such as fracture joint or fluvial related spring etc. (as given in Valdiya & Bartarya, 1991) or on types of aquifer. • Regarding, suggestion on use of "tracers and isotopes as another tool", it is not possible to consider this suggestion in this study. However, this suggestion could be well taken in a separate study.
37th WGM No any specific suggestion/comment	NA
38th WGM No any specific suggestion/comment	NA

12. **Analysis and Results**

- Spring flow data for 20 springs in Chandrbhaga Watershed and 30 springs in Danda watershed has been obtained from previous studies. These time-series data sets have been checked for consistency and accuracy of the records.
- Various statistical parameters such as maximum flow discharge, minimum flow discharge, average flow discharge, mode, median, standard deviation, lower 95% confidence interval of average discharge, upper 95% confidence interval of average discharge, variance, skewness, kurtosis, coefficient of variation, mean absolute deviation and probability of flow at 90%, 95% and 99% (i.e. P90, P95 and P99). The detail will be given in the WG meeting.
- A fully automated objective-based method (adapted matching strip method) was chosen for Master recession curve separation. This program extensively checked for the accuracy and necessary debugging is carried out. Using this program, preparation of master recession curves for all the springs in the Chandrabhaga and Danda Watersheds has been completed. The FDC plotted for entire time series has been used to select two probable ranges of percent of flow rate in order to facilitate optimal separation of MRC into three recession segments. Consequently, the Recession constants estimated for the springs in Chandrabhaga and Danda Watershed are given in following Tables 1 and 2, respectively.

Table 1. Calculated Recession constants (k) and correlations coefficients (R^2) for springs in Chandrabhaga Watershed using MRC.

Spring ID No.	MRC by Exponential equation	Optimal separation model Q%	Recession constant when MRC separated into three segments	R^2 values for each separated segment of MRC

											and optimal MRC
	k	**R2**		k_1	k_2	k_3	k	**Seg 1**	**Seg 2**	**Seg 3**	**Optimal**
1	0.978	0.93	14% and 56%	0.981	0.985	0.975	0.980	0.76	0.71	0.91	0.93
2	0.980	0.93	16% and 53%	0.980	0.987	0.979	0.980	0.75	0.85	0.90	0.94
3	0.966	0.90	1% and 27%		0.984	0.968	0.980		0.69	0.89	0.92
4a	0.959	0.84	2% and 46%		0.961	0.961	0.957		0.70	0.81	0.92
4b	0.960	0.84	4% and 76%		0.957	0.968	0.970		0.75	0.82	0.90
5	0.976	0.80	6% and 75%	0.946	0.972	0.977	0.970	0.86	0.62	0.84	0.88
6	0.985	0.89	4% and 75%	0.974	0.984	0.984	0.990	0.90	0.76	0.70	0.87
7	0.970	0.93	19% and 90%	0.959	0.973	0.971	0.970	0.51	0.90	0.85	0.95
8	0.978	0.93	42% and 83%	0.974	0.980	0.979	0.977	0.80	0.85	0.72	0.96
9	0.970	0.84	2% and 76%	0.957	0.976	0.958	0.970	0.87	0.70	0.55	0.81
10	0.973	0.93	3% and 31%	0.963	0.978	0.968	0.980	0.75	0.87	0.84	0.90
11	0.966	0.89	3% and 32%	0.944	0.964	0.949	0.961	0.94	0.81	0.78	0.90
13	0.966	0.88	7% and 45%	0.967	0.977	0.953	0.960	0.73	0.84	0.62	0.80
14	0.977	0.79	13% and 47%	0.976	0.966	0.983	0.973	0.86	0.85	0.43	0.80
15	0.984	0.85	16% and 47%	0.969	0.994	0.977	0.984	0.87	0.59	0.82	0.87
16	0.981	0.88	20% and 96%	0.981	0.977	0.976	0.977	0.78	0.88	0.99	0.95
17	0.972	0.91	26% and 64%	0.967	0.983	0.980	0.975	0.92	0.71	0.82	0.96
18	0.980	0.90	32% and 58%	0.962	0.971	0.966	0.968	0.81	0.83	0.63	0.93
19	0.979	0.63	70% and 82%	0.969	0.988	0.964	0.967	0.89	0.64	0.91	0.95
20	0.970	0.96	31% and 94%	0.972	0.973	0.993	0.972	0.68	0.96	0.86	0.98

Table 2. Calculated Recession constants (k) and correlations coefficients (R^2) for springs in Danda Watershed using MRC.

Spring ID No.	MRC by Exponential equation		Optimal separation model Q%	Recession constant when MRC separated into three segments				R^2 values for each separated segment of MRC and optimal MRC			
	k	R2		k_1	k_2	k_3	k	Seg 1	Seg 2	Seg 3	Optimal
1	0.964	0.91	9% and 45%	0.967	0.978	0.961	0.957	0.94	0.69	0.73	0.94
2	0.980	0.73	10% and 47%	0.973	0.985	0.991	0.971	0.95	0.51	0.26	0.87
3	0.951	0.85	5% and 45%	0.957	0.953	0.965	0.953	0.98	0.75	0.86	0.93
4	0.972	0.75	34% and 59%	0.981	0.989	0.962	0.970	0.67	0.65	0.83	0.84
5	0.989	0.59	5% and 53%	0.976	0.967	0.996	0.989	0.92	0.69	0.68	0.65
6	0.949	0.96	3% and 15%	0.893	0.936	0.949	0.947	0.96	0.79	0.96	0.97
7	0.934	0.93	5% and 30%		0.903	0.953	0.938		0.90	0.90	0.95
8	0.958	0.90	25% and 49%	0.939	0.983	0.948	0.955	0.80	0.68	0.81	0.94
9	0.955	0.93	16% and 67%	0.951	0.948	0.960	0.951	0.63	0.89	0.87	0.97
10	0.975	0.86	22% and 44%	0.930	0.977	0.978	0.971	0.78	0.76	0.80	0.91
11	0.988	0.81	5% and 35%	0.944	0.990	0.984	0.984	0.95	0.73	0.81	0.88
13	0.982	0.73	1% and 39%		0.950	0.983	0.974		0.74	0.67	0.90
15	0.984	0.73	6% and 98%	0.899	0.963	0.996	0.984	0.90	0.88	0.96	0.64
16	0.974	0.85	3% and 22%		0.986	0.976	0.969		0.91	0.86	0.92
17	0.974	0.77	18% and 99%	0.952	0.965	0.996	0.971	0.77	0.96	0.99	0.91
18	0.976	0.70	2% and 37%		0.986	0.973	0.973		0.37	0.86	0.92
20	0.984	0.81	2% and 28%		0.960	0.984	0.981		0.72	0.82	0.86
21	0.980	0.72	3% and 26%		0.885	0.983	0.979		0.76	0.68	0.73
25	0.977	0.87	3% and 28%		0.952	0.979	0.974		0.82	0.78	0.86
27	0.973	0.80	30% and 90%	0.971	0.977	0.990	0.972	0.93	0.75	0.97	0.94
28	0.974	0.89	19% and 74%	0.974	0.973	0.950	0.968	0.98	0.83	0.44	0.86
29	0.945	0.95	7% and 28%		0.946	0.951	0.949		0.86	0.98	0.98
30	0.944	0.97	4% and 77%		0.951	0.954	0.950		0.92	0.98	0.98

Estimation of Recession Constants Using Seasonal Spring Flow Records

In order to check the reliability as well accuracy of the separation of MRC in two/three segements(see Tables 1 and 2), estimation of recession constants has been carried out using seasonal spring flow records. In case of separated MRC in three segments, it is assumed that out of these three segements, first segement represents MRC of rainy season, second segement epresents MRC of winter season and third segement represents MRC of summer season. To understand the annual and season variability and availability of spring discharge through time, the flow duration curves (FDC) have been plotted for all the spring. Duration curve for month grouped into three seasons (1) Summer or pre-monsoon season (March to 15th June) (2) Monsoon or rainy season (June (2nd half to September), and (3) winter season (October to February) for seasonal analysis of the daily discharge data. The estimated seasonal recession constants and respective coefficient of determination (R^2) for the springs in the chndrabhaga and Danda watershed are shown in Figure 1.

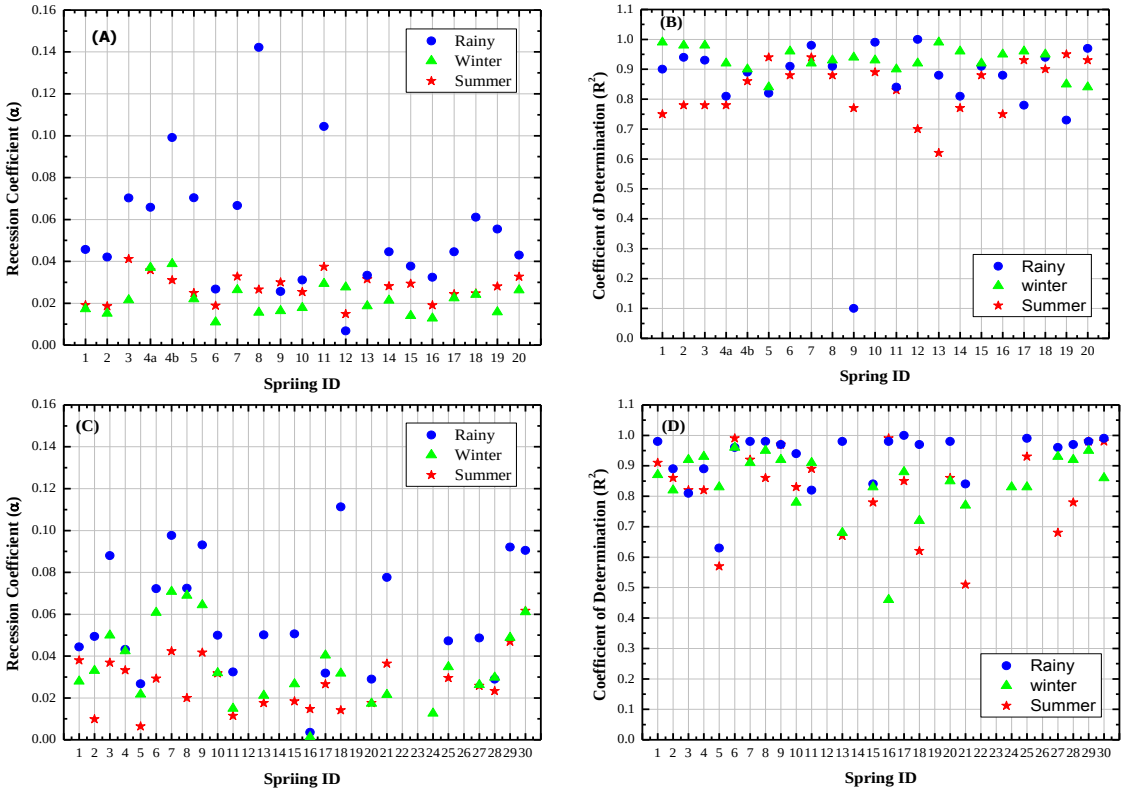


Figure 1. Seasonal recession constants and coefficient of determinations of the springs in the Chandrabhaga (A & B) and Danda Watersheds (C & D), respectively.

- Characterization of springs in study area was done through spring flow variability and low flow variability index using FDC. The brief results for Rupado spring (Spring ID # 6, Danda Watershed) are demonstrated here and results for all the spring will be presented in WG meeting. The minimum, maximum and average value of discharges with their date of observation of the Rupado spring for entire period from August 1999 to December 2004 and seasonal time series for this period is given in Table 3.

Table 3. The Observed Minimum, Maximum and Average Discharge Values and Date of Observations for Different Period of Time-Series.

Time-series observation period	Min. discharge (lps)	Date	Max. discharge (lps)	Date	Average discharge (lps)
Entire	0.0027	28-Apr-04	0.7937	11-Aug-00	0.0998
rainy season	0.0066	21-Jun-01	0.7937	11-Aug-00	0.1856
Winter season	0.0040	28-Feb-04	0.5000	15-Oct-04	0.0824
				19-Oct-04	

				23-Oct-04	
Summer season	0.0027	28-Apr-04	0.5000	2-Mar-01	0.0350

The flow duration curve of the spring for entire period and selected separation criteria ranges when separation is performed on three MRC's is shown in Fig. 2. Similarly, the seasonal FDC's namely for rainy season, winter season and summer season for the period from August 1999 to December 2004 are shown in Fig. 3. Fig. 4 represents the separated MRC's for the rupado spring having optimal separation criteria, calculated as 3% and 15% of the flow rate duration, respectively. Similarly, the plot of MRC's using exponential decay function is shown in Fig. 5. On the plot of MRC's (Figs. 4 and 5), the exponetial decay equation for each separated segment and for each seasonal MRC and respective goodness of fit is given. Subseqently, the average values of recession coefficient (α_i), recession constant (k_i) , flow half life period in days ($t_{1/2}$) and spring flow at the start and end of MRC recession segement/ seasonal MRC for Rupado spring are shown in Table 4. Similar analysis has been cariied out for all the springs in both the watersheds.

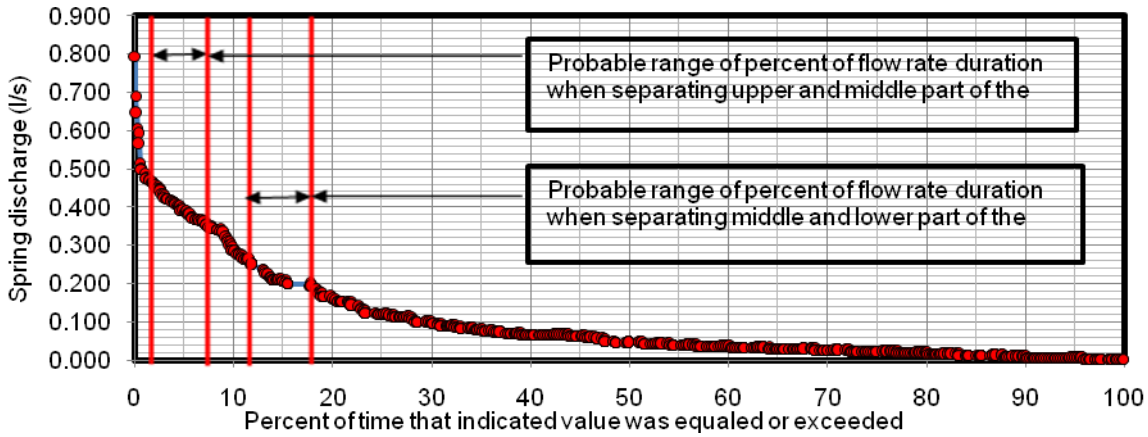


Figure 2. Flow duration curve of the Rupado Spring (ID No.6) for period 1999-2004 and selected separation criteria ranges when separation is performed on three MRC's.

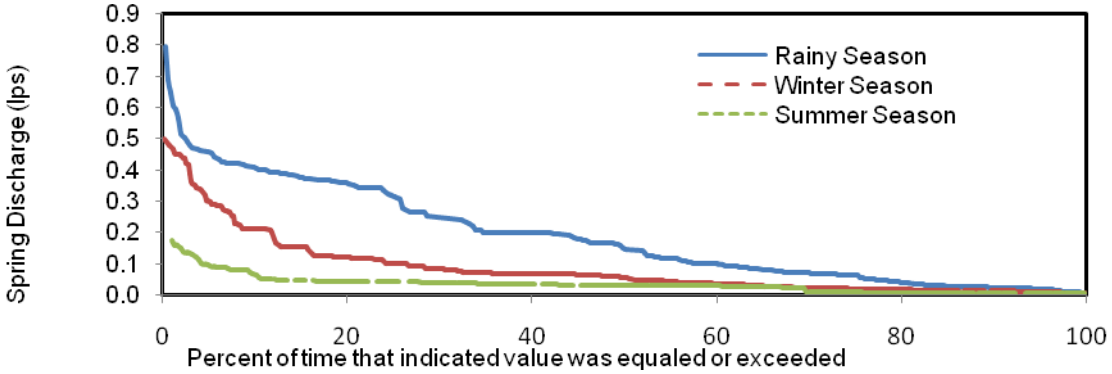


Figure 3. Seasonal flow duration curve of the Rupado spring for the period 1999-2004.

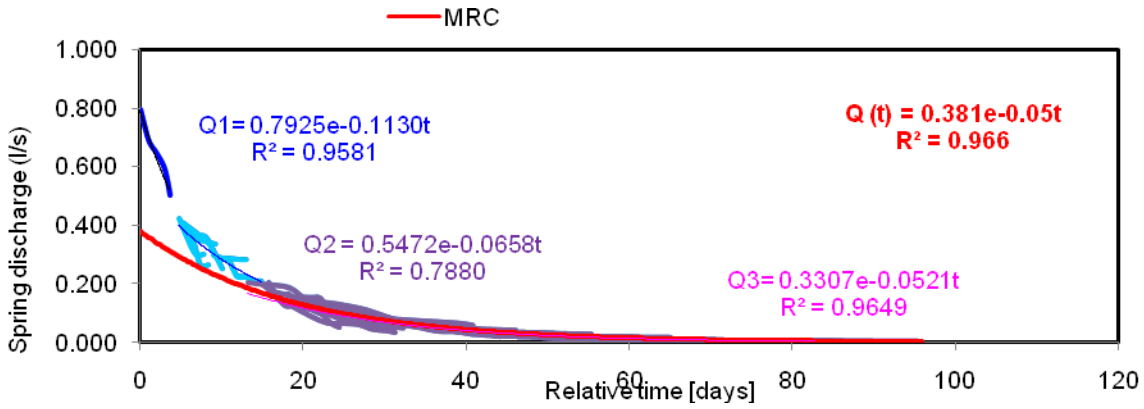


Figure 4. The separated MRC of the Rupado spring for the period 1999-2004 when separation is performed on three MRC's.

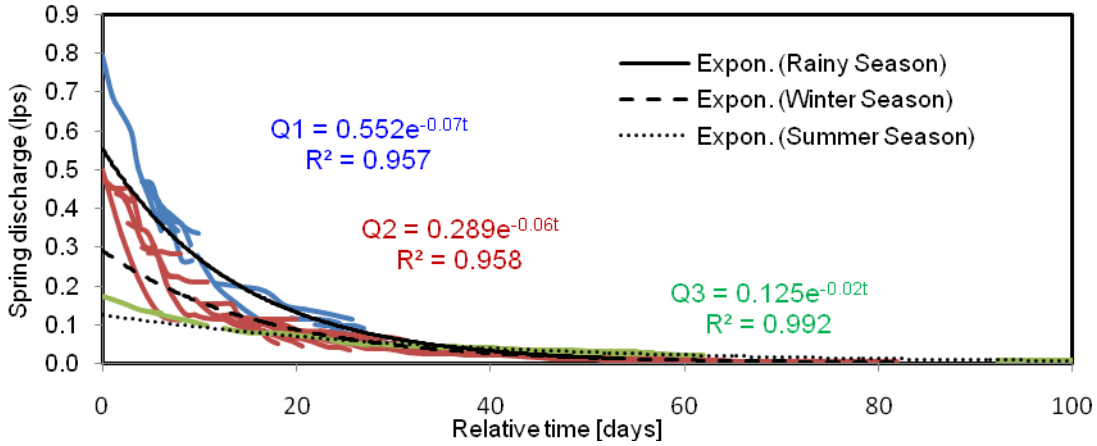


Figure 5. Seasonal MRC of the Rupado spring for the period 1999-2004.

Table 4. The Average Values of Different Recession Parameters and Spring Flow at the Start and End of MRC Recession Segement/ Seasonal MRC For Rupado Spring.

MRC		Recession coefficient (α_i)	Recession constant (k_i)	Coefficient of determination (R^2)	Flow half life, (days) ($t_{1/2}$)	Spring flow discharge values (lps)	
						Start of recession period	End of recession period
Entire time-series	Segment 1	0.113	0.893	0.9581	6	0.794	0.502
	Segment 2	0.066	0.936	0.7880	10	0.422	0.209
	Segment 3	0.052	0.949	0.9649	13	0.206	0.003
	Average	0.055	0.946	0.966	13		
Rainy season		0.072	0.930	0.96	10	0.794	0.500

Winter season	0.061	0.941	0.96	11	0.500	0.172
Summer season	0.029	0.971	0.99	24	0.172	0.003

- To measure the variability of spring flow, the ratio of (Q_{10}/Q_{90}) proposed by Netopil (1971) is being used. The (Q_{10}/Q_{90}) value for Rupado spring is 37.4. which indicates high flow variability. The low flow variability measured by (Q_{50}/Q_{90}) ratio is also 5.88 which indicates relatively low variability of Rupado spring. Similarly, the analysis of the variability of all the springs have been carried out.

Estimation of Base Flow Index (BFI)

Digital filters are useful tools for assessing the contribution of groundwater to total river/spring flow. Several of those filters have been proposed in the last decades. One of the last contributions on this subject was given by Ekchardt (2005) who proposed a more general form of a digital baseflow filter and showed that some of the most used filters are special cases of this general form. Eckhardt (2005) proposed a general form of the digital filtering method with representative $BFI_{\max}$ (maximum value of long term ratio of baseflow to total stream flow) parameter values for various hydrogeological situations to minimize the subjective influence of using $BFI_{\max}$ on baseflow separation. Eckdhardt (2005; 2012) estimated representative $BFI_{\max}$ values for different hydrological and hydro-geological situations. He proposed the use of $BFI_{\max}$ values of 0.80 for perennial streams with porous aquifers, 0.50 for ephemeral streams with porous aquifers and 0.25 for perennial streams with hard rock aquifers. To our knowledge no any study has been carried out which uses spring flow records to test these values of parameters.

Ekchardt (2005 and 2012) recommended the use of recursive filter parameters such as α (recession constant) and $BFI_{\max}$ value which are specific to local condition. Therefore, the $BFI_{\max}$ and recession constant (filtering parameter) values are estimated using inverse recursive filter and fully automatic adaptive matching strip methods, respectively. Similarly, the BFI values using Eckdhardt suggestion has been carried out. Further, the results obtained with Eckhardt recursive digital filter and modified Eckhardt recursive digital filter are compared with those obtained using Web based WHAT model, $BFI_{\max}$ optimization available in WHAT model and $BFI_{\max}$ value optimized with Genetical Algorithm (GA). Typical results are shown here for spring ID#6 in Danda watershed and Spring ID#4a in the chandrabhaga watershed in Figs. 6 and 7, respectively. Similarly, the analysis for all the spring has been carried out.

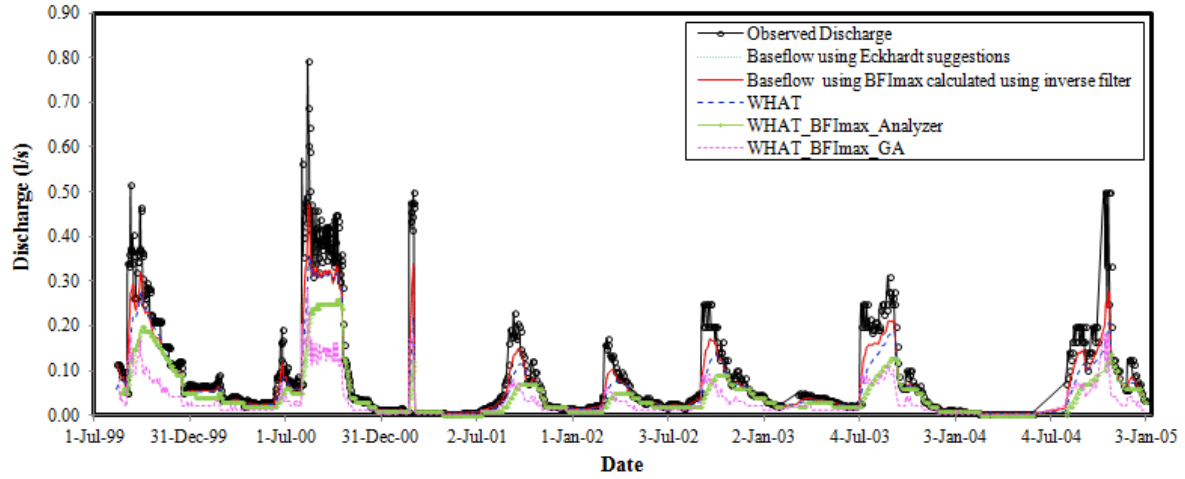


Figure 6. Baseflow separation digital filtering methods using various methods (Spring ID#6, Rupado spring in the Danda Watershed).

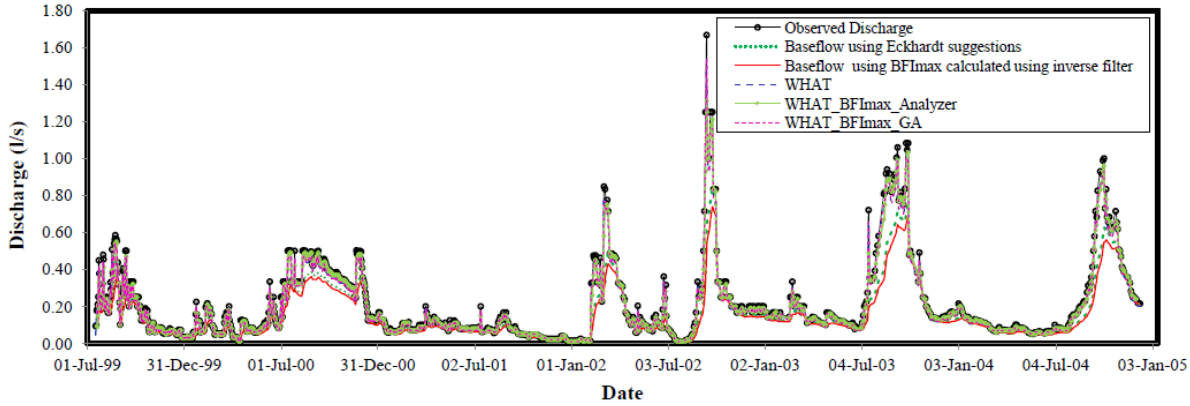


Figure 6. Baseflow separation digital filtering methods using various methods (Spring ID#4a, Bainsoli Malli spring in the Chandrabhaga Watershed).

Estimation of Aquifer Parameters

Using the estimated recession constants for all these springs, prediction of aquifer parameters by using the hybrid model such as topographic module to estimate morphological parameters of the spring watersheds with the help of RS and GIS and hydrological module is under progress and attempt will be made to complete the task before WG meeting. Presently, almost 60% work is completed on this task.

13. **Adopters of the results of the study and their feedback**

    N.A. at present

14. **List of deliverables** (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users interaction workshops)
    a) Papers
    b) Report: Interim report is prepared during April/May 2013.

Research Paper published or accepted out of this research project are as follow:

1. **Kale R. V.** and Goyal, V. C. (2013), Recession Flow Analysis for Assessment of Springs, In Proceeding "Efficient Water Management: Challenges and Opportunities", India Water Week – 2013, held at Vigyan Bhawan, New Delhi on 8-12th April 2013 (Full length paper is published in soft copy format).
2. **Kale R. V.** and Goyal, V. C. (2013),Estimation of recession constants for the springs in a Himalayan Watershed, 8th International Conference of European Water Resources Association (EWRA) on " Water Resources Management in an Interdisciplinary & Changing Context" Porto Portugal, 26-29th June, 2013.
3. **R. V. Kale** and V. C. Goyal (2013) Estimation of recession constants for springs in danda watershed (uttrakhand), International Conference: AWRDM-2013 "Advances in Water Resources Development and Management" Chandigarh, India, October 23-27, 2013. [Accepted].

15. Major items of equipment procured : NIL

16. Lab facilities used during the study: NIL

17. Data procured and/or generated during the study

The following are the data requirement for the analysis of spring flow data using recession flow model

a) Daily precipitation and spring flow data
b) Information on catchment characteristics

These information's have been collected from previous study reports by NIH

18. Study Benefits/Impact (2-column table showing achievements against measurable indicators as mentioned in the approved study document)

Measurable indicators	Expected achievements
New technologies/processes	This study will provide improved methodology for analysis of spring flow data series in order to analyze the water resources availability in the study region.
Improvement in skill	It is expected

19. Specific linkages with Institutions and/or end-users/beneficiaries

NIL

20. Shortcomings/difficulties, if any

There is some difficulty encountered during the estimation of aquifer parameters and hence, there is delay in the completion of this task within the stipulated period.

21. Future plan

To be evolved at later stages of the study.

Study - 2

Title of the study:

Pilot Basin Studies in Identified Sites at Six RCs/CFMSs (**Continuing Study**)

2. **Name of PI, Co-PI, & their affiliations**

   Leader: Dr. V. C. Goyal, Sc F and Head, RCMU
   PI : One each from Divisions at the HQs and RCs/CFMSs

3. **Type of study**
   Internal (Jointly undertaken by NIH HQs and RCs/CFMSs)

4. **Date of start:** April 2012

5. **Scheduled date of completion:** March 2015

6. **Study Area:** Total six pilot basins (one at each RCs and CFMSs) has been selected in consultation with the respective state government in which selected pilot basin is falling to address the existing water-related problems. The details about these pilot basins have been given in the Table 1.

7. **Study objectives**
   NIH proposed to undertake six Pilot IWRM Basin studies in different locations covering various agro-ecological regions in India (See Figure 1). With availability of its functional field units in these regions (RCs and CFMSs), NIH plans to establish advanced instrumentation systems for data collection and storage from these Pilot Basins. Analysis and modelling using state-of-art software models would be carried out on the data collected to derive meaningful results and findings for ultimate implementation and use by the stakeholders. With the help of specialists from other disciplines, the various stakeholders, including the local community, would be involved at different stages of planning, execution, evaluation, impact assessment, etc. It is hoped that the pilot studies would provide useful insight into the propagation of IWRM concept for sustainable development of water resources with community participation, which could be replicated in other areas.

   The proposed study aims to:

   i. establish advanced instrumentation systems for data collection and storage,
   ii. carry out analysis and modelling using state-of-art software models,
   iii. develop IWRM concept for sustainable development of water resources with community participation, which could be replicated in other areas.

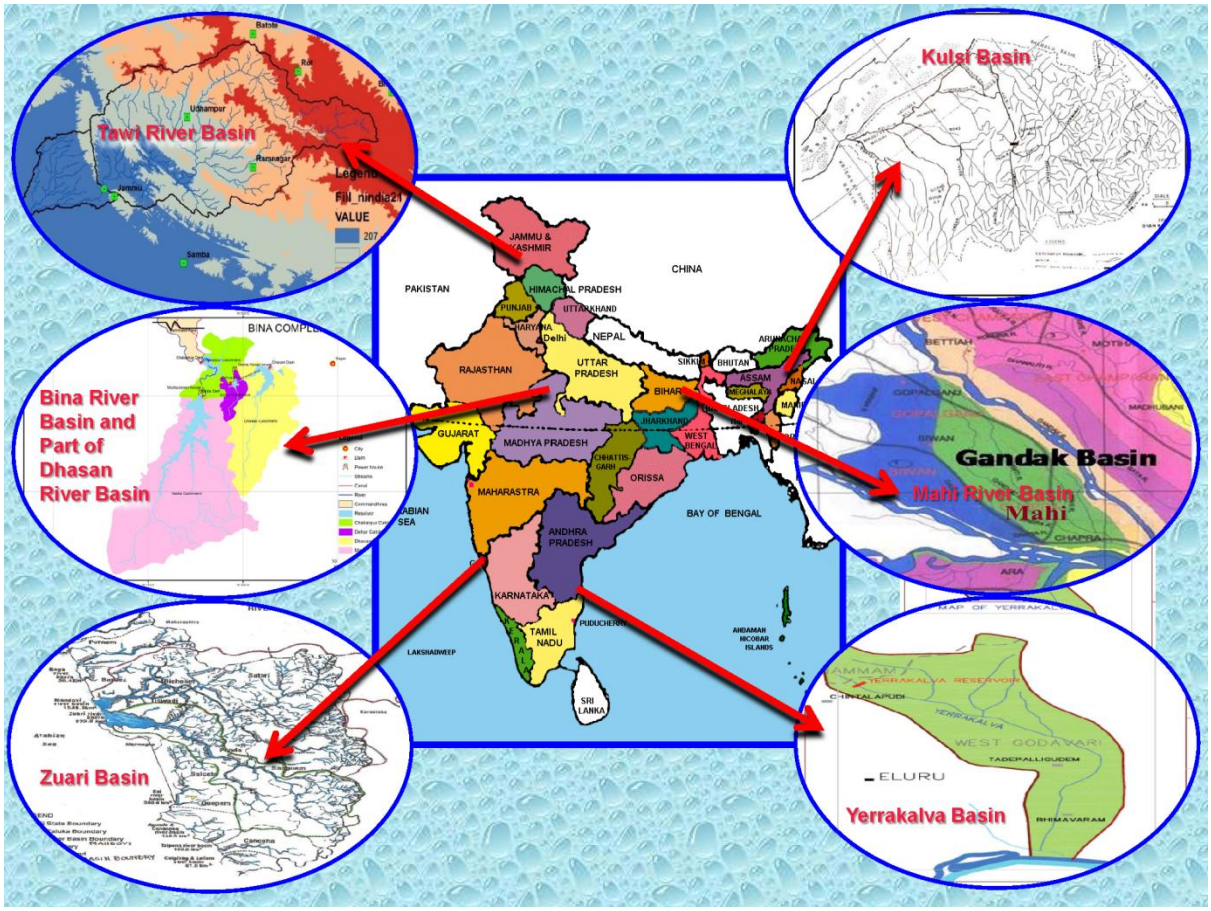


Figure 1. Pilot basins selected under IWRM-PBS program of NIH by its different RC/CFMS.

Achievements:

- Identification of pilot basin after confirmation from respective state government has been completed by all the RCs/ CFMS. As per the program required to be achieve, one-day brainstorming session with the stakeholders (both Govt. & Non-Govt.) has been organized by Kakinada, Belgaum, Bhopal, Patna and Jammu regional centre/CFMS of NIH. Beside this, NIH Regional Centre, Bhopal **organized** one day workshop on “Water Conservation in Bina Sub-basin in Bundelkhand Region (MP)” at Bina on 27-09-2013. As the Ministry of Water Resources, Govt. of India has declared the year 2013 as “**Water Conservation Year**” under which some activities have been planned to create awareness about Water conservation among common people during this workshop. Sh. Karmaveer Sharma, IAS, Sub-Divisional Magistrate of Bina was invited as Chief Guest and Sh. K.P. Mishra, Sr. Manager (HR), Bina Oil Refineries Ltd. Bina was invited as Special Guest in the workshop. During this workshop, Sh. Karmaveer Sharma assured full support from the administration in respect of field data and publicity/implementation of research

findings. The participants from various departments / organization / academicians / NGO's working in the field of water resources in the Madhya Pradesh State as well as experts from the Central Ground Water Board (CGWB), Central Water Commission (CWC), Maulana Azad National Institute of Technology (MANIT), Central Soil Science Research Institute (CSSRI), Madhya Pradesh, Council of Science & Technology (MPCST), Water Resources Department, State Groundwater Survey Department, Panchayat & Rural Development Department, Forest Department etc. are participated in the discussion. The details about the one-day brainstorming session and workshop organized at different place by RCs/CFMS along with date and emerged water management issues are given in following Table.

a) The session was structured as follows:
   - IWRM and PBS concept
   - Identification of gaps and issues
   - Proposed work plan and deliverables
   - Stakeholders' role and participation

Pilot basin, RC/CFMS name, Venue of meeting and date of brainstorming session	**Emerged Water Management Issues**
Yerrakalva Basin, Andhra Pradesh **Deltaic Regional Centre, Kakinada** Meeting Hall, Data Centre, Eluru 31st Aug. 2012	• Water level depletion in the upland areas, water logging in delta areas and ground water salinity in the delta areas • Need of micro-level surveys on the impact of aquaculture on shallow aquifers • Demarcation of saline-fresh water interface has to be established in the coastal areas of the basin to avoid further degradation of groundwater quality • There is a necessity of a technique to find a way to safely dispose peak floods through Yerrakalva due to condition that the Yanamadurru drain has a discharge capacity of 8,000 cusecs and aqueducts built across the Yerrakalva river were designed for 20,000 cusecs at Nandamuru aqueduct and 1,50,000 cusecs at ISRMC crossing. • The major challenges to be addressed: groundwater issues of over exploitation in uplands; water logging in delta command area; water quality problem due to aquaculture; sea water intrusion into coastal aquifer etc. • Flood problem in the basin and back water effect due to old aqueduct at Chintaluru. • Need of lift irrigation schemes to mitigate flood problem • Poor quality of upstream waters of Yerrakalva basin • Scarcity of water during summer period

Bina river basin and part of Dhasan river basin of Betwa river in south Ganga plains **Ganga Plains South Regional Centre, Bhopal** WALMI Campus, Bhopal 29th Nov., 2012	• Water conservation for the entire post-monsoon requirements • Integrate social aspects in IWRM programme with thrust on socio-techno implementation activities • Regional hydrological formula for un-gauged basins in semi-arid regions required for water resources development in the region • Need of developing an institutional mechanism for better management of water resources in a basin • Sharing of natural resources data to be used in open software for DSS which can help in carrying out spatio-temporal changes and • Identify the gaps in resource data • Holistic approach is necessary for the water resources development of the region • Assessment of socio-economic impacts • Integrated development of habitats • Science communicators for spreading the awareness and conducting capacity building program in rural areas • Creation of Water Users Associations in command areas • Development of field channels and water courses • Proposal of AIBP programs for major and medium projects • Involvement of villagers and NGO's in the planning stage • Rules preparation for safe ground water exploitation • GW pollution aspects • Crop simulation modelling • Impact of land use change • Water quality studies • The methods and techniques available with CWC for Gauge & Discharge measurement, silt observation and water quality monitoring in river can be extended to NIH.
One day workshop on "Water Conservation in Bina Sub-basin in Bundelkhand Region (MP)" held at Bina on 27-09-2013	• Declining groundwater, floods during monsoon in contrast with dry river in summer months. • Bina Oil Refineries Ltd. (BORL) Bina expressed concern over water scarcity in some villages during the summer months. Sr. Manager (HR), BORL informed that BORL has adopted eighteen villages surrounding to the refinery and requested NIH RC Bhopal to prepare a comprehensive water resources development & management plan for at least two villages initially. • The lower Segment of Bina Sub-basin has sufficient water throughout the year, except in June, when the flow in the river is practically nil. However, depressions in the river bed contain sufficient water for drinking and domestic purposes. • It was opined that some water conservation practices are

	required at the upstream reaches and in the catchment area to prolong the river flow during summer months. • The quality aspect was also discussed and no reports were found about fluoride/Arsenic/Heavy metals in water or any water born disease.
Zuari Basin, (Goa) **Hard Rock Regional Centre, Belgaum** State Hydrology Data Centre (Water Resources Department), Porvorim, Panaji 27th Nov. 2012	• Increasing salinity levels in the river and occurrence of flash floods • Water availability and water quality deterioration during lean periods • Water availability and water quality deterioration during lean periods • Change in land cover due to urbanization and mining activities within upstream reaches • Competing demands for water resources need to be analyzed more comprehensively to arrive at better methodologies and tools for understanding the hydrology of the region • Effect of mining on downstream river reaches • Siltation in reservoir due to mining • Rejuvenation of springs • Increasing levels of manganese in drinking water • Water use efficiency • Estimation of ET for the u/s reaches • Computation of runoff coefficient, infiltration, percolation etc. • Intensity-Duration-Frequency analyses • Environmental Flow Requirement • Salinity ingression into u/s river reaches • Control of evaporation from tanks/reservoirs • Identification of recharge zones • Effect of artificial recharge structures • Hydro-geological mapping • Crop water requirement • Salinity in estuarine region • Reclamation of salinity affected zones • Influence of land use changes on water resources • Effect of mining on acrecanut garden • Evaluation of pollution levels • Demarcation of zones of fresh water for fisheries • Water quality for agriculture • SRI system of agriculture • Introduction of micro-irrigation methods to reduce crop water requirement • Estimation of silt inflow • Watershed management/soil conservation • Utilisation of irrigation return flow • Effectiveness of bandharas in rivers • Management of abandoned mines

	• Influence of tides • Fresh water-saline water wedge • Agricultural pollution • Estuarine ecology • Identification of water quality hot spots • Demarcation of erosion potential zones
Mahi River Basin in Ghaghra-Gandak Composite Basin Centre for Flood Management Studies (CFMS), Patna 21st December, 2012	• Main problem is drainage congestion • Mahi river originated from the chaur needs to be made free from water logging by forced drainage • Flood inundation mapping due backwater effect of Ganga river studies during flood. • Water management studies for sustainable agriculture. • Assessment of WQ parameters like Arsenic, Fluoride, Nitrate etc. and pesticides for safe drinking and irrigation needs
Tawi River basin(Jammu) Western Himalayan Regional Centre, Jammu PWD Conference Hall, Jammu 16th April, 2013	• The water availability is declining in the Kandi belt of the Shiwaliks and water level of lakes and ponds is also depleting in the region. • Rainwater harvesting particularly on the upside of the national highway could be undertaken • Base flow and sub-surface water required to be trapped. Basic water harvesting structures like check dams, gully plugs, gabions, and earthen bunds required to be promoted in Kandi belt • This region also receives a very good amount of rainfall but within few hours all water goes to the neighbouring country as a runoff. Efforts should be made to retain this rainwater for longer periods in this region • Advanced forecasting of weather, floods etc. are some of the very important issues • Assessment of the present and future water availability assessment in the rivers • Rainwater harvesting is very important aspect of any water management plan • Many of the water resources development projects of the state are lacking behind the schedule due to improper planning and implementation • Increasing demand and decreasing water availability, • Floods/flash floods are the major problem • Need of water resources development projects • River ecology should be studied in details • Lack of proper meteorological network, • Collaborations for instrumentation is required • CWC is collecting discharge data in Tawi River since 1976 on trice daily basis at the second bridge of Tawi (near Vikram Chouk).

	• Direct sewerage of the Jammu city dumping into the Tawi is a major cause of water quality deterioration. • The accuracy and adequacy of rainfall and discharge data available in the Tawi catchment required to be verified • Studies regarding the natural spring of Tawi catchment should be incorporated • NGO, civil societies and People participation is needed for converting making water conservation drive into a movement • The time frame and next five year action plan of IWRM for Tawi River can be prepared • The lack of implementation of central government schemes on field • Village Nallahs can be facilitated with check dams to conserve water for irrigation and village • Lack of co-ordination among the state agencies • Community participation and awareness is very important for IWRM • Necessity of alternative sites for religious rituals to avoid water quality deterioration of Tawi River during Navratra • Setup of Effluent Treatment Plants (ETPs) and Common Effluent Treatment Plants (CETPs) for Industrial waste water • study of the Tawi catchment at micro-level to monitor and evaluate the performance of the various soil and water conservation measures • CGWB informed that they are also planning to install instrument for ground water level monitoring and information can be shared with NIH. • The surface water - ground water interaction studies can be a part of this IWRM programme.
Kulsi basin (a part of the Brahmaputra sub-basin) Centre for Flood Management Studies (CFMS), Guwahati	Under Process

b) Preparation of detailed Status Report on the PBS as part of work program at each RC and CFMS during 2012-13 was outlined to cover the following points:
   - Statement of the problem
   - Review of studies carried out (by RC/CFMS (NIH) and other agencies)
   - Identification of gaps

- Proposed study components to address the gaps
- Data requirement for the study components and proposed instrumentation
- Work plan and time line

Achievement: Draft of status report were submitted by the following RC/CFMS

a) Deltaic Regional Centre, Kakinada
b) Hard Rock Regional Centre, Belgaum
c) Centre for Flood Management Studies (CFMS), Patna
d) Ganga Plains South Regional Centre, Bhopal
e) Western Himalayan Regional Centre, Jammu

Status report by RC Guwahati is under progress.

Brainstorming Session: The brainstorming session on "**Stakeholders Cooperation and Participation in Developing IWRM Action Plan**" was held at India Habitat Centre (Amaltas Hall), New Delhi, during March 21-22, 2013 under the Chairmanship of Director, NIH. The brain storming session was attended by number of experts from diverse fields related to integrated watershed management. During formal inaugural function, Director NIH welcomed Mr Shigeru Aoyagi, Director, UNESCO (Chief guest), Dr D Dutta, Director, CEFIPRA (Distinguished Guest) and all other experts participated in the brainstorming session. The various issues emerged during this brainstorming sessions are given briefly as below.

Sr. No.	Speaker	Emerged water management related issues
1.	R. D. Singh, Director, NIH Roorkee	• It is attempt to showcase the state of art instrumentation program for the Government departments. • First identify the needs of stakeholders and then study its optimal allocations and feasibility • Do water balance studies in all the PBS
2.	Mr Shigeru Aoyagi, , Director, UNESCO	• Education is necessary for sustainable development and change of mind sets • Learning process is necessary during IWRM • PBS-IWRM studies can be designed by taking lesson from IHP, HELP Program • Need of Water cooperation and water collaboration
3.	Dr D Dutta, Director, CEFIPRA	• IWRM involves association of various institutes: government and non-government organizations dealing with socio-economic, environmental, health and legal issues and various stakeholders who are actual user of water. • Technical capacity building is important component in any IWRM. • There is difference between urban and rural watersheds and need to be studied scientifically. • Livelihood is an important component which needs to be addressed on priority basis in an IWRM project.

		• Planning of water supply from different water bodies instead of single reservoir should be considered for various domestic as well as industrial uses. • Information's gathered during IWRM studies are important in the consultative process of Planning Commission. • Acquire local knowledge about spatial and temporal changes within hydrological unit.
4.	Dr Ram Bhooj, UNESCO	• UN thematic consultation on water, namely Water, Sanitation and Hygiene (WASH); Water Resources Management; and Wastewater and Water Quality. • Climate change is a real and growing threat. Without good planning and adaptation, hundreds of millions of people are at risk of hunger, disease, energy shortages and poverty. • Governance matters for improved management of water resources; including the management of transboundary aquifers. • There is a shortage of capacities on water governance and integrated water management remains an important challenge. • IHP VIII 2014-2019, aims to improve water security in response to local, regional and global challenges which reflects a deeper understanding of the interconnections between the water-energy-food nexus with the goal to further improve Integrated Water Resources Management (IWRM) • Role of human behavior, cultural beliefs, attitudes towards water, need for research in social and economic sciences and tools to adapt to human impacts on changing water availability are challenges that required to be addressed in IWRM • NIH can collaborate with the Mahatma Gandhi Institute of Education for Peace and Sustainable Development (MGIEP), New Delhi (a UNESCO's specialized education institute in category 1 which is linked to implement post 2015 agenda of UNESCO.
5.	Ms. Veronica Albuja, UNESCO	• HELP is a cross-cutting programme component: it interacts with all five core themes of the International Hydrological Programme ▪ Adapting to the impacts of global changes on river basins and aquifer systems ▪ Strengthening water governance for sustainability ▪ Ecohydrology for sustainability ▪ Water and life support systems ▪ Water education for sustainable development

		• The programme works in close cooperation with the World Meteorological Organization (WMO), and the Global Energy and Water Cycle Experiment (GEWEX). • Aim of HELP program is to deliver social, economic and environmental benefit to stakeholders through sustainable and appropriate use of water by directing hydrological science towards improved integrated catchment management basins. • UNESCO provided technical support to Pan Himalayan Grassroots organisation to implement IWRM project in the Ganga basin that was trapped in a cycle of water and food insecurity, leading to health issues among the population and a deteriorated quality of life. • Cooperation with National and international Institutes is necessary
6.	Ms Anupama Datta, HelpAge India	• Consider involvement of PRI, volunteers/communicators • Quality involvement is also an important issue. • Form a committee at all six pilot basins • Use of right communication means • Village community may not follow the saying of outside person but they follow the saying of person from the same village community
7.	Dr A J James	• Lessons learnt from Implementation of IWRM in Rajasthan suggests that the following issues need to be addressed in the IWRM ▪ demand management ▪ problem of governance ▪ formation of Gram Panchayat committees for rehabilitation & village water bodies ▪ political functioning ▪ concept of Geo-fencing ▪ social regulations ▪ development of thumb rule for planners, managers for the quantification of water supply, demand and withdrawal. • Water Audit should look at all water uses. Check IRS website (http://www.irc.nl) for multiple uses of water. • Prepare GP level plan. Ensure more community involvement. • Forecast of things happening in future • Study Australian IWRM projects • Approach to CM and CS for implementation of IWRM plan • Water demand from the urban area is the main culprit

		in water resources management in rural watersheds.
8.	Dr Priyani Amarasinghe, IWMI	• Signing of MOU with the stakeholders • Lessons can also be learned from SUJALA project carried out by IWMI • Study of IWRM in Tungbhadra project may be referred in formation of PBS-IWRM • Health issues need to be addressed in the IWRM • Formation of community health groups • Indentify clear process plan to involve stakeholders and process plan should be agreed by all the stakeholders. • Instrumentation should come after the process plan • Design multi-stakeholders engagement plan in IWRM activity. • Prepare eco-system development plan. • Students should be involved at local level for PBS activities.
9.	Dr R Saravanan, CWR, Anna University	• Anna University has started certificate course on IWRM • Agreed to share course material with NIH. • Consider geological formations prevailing in project areas for network design to observe heterogeneity.
10.	Dr Shibu Mani, TISS	• Start with process and then start with instrumentation. Plan measurement network with the help of local peoples. • Mix peoples concern with complex models • Short term and long term benefits should be decided • Focus on existing institutional frame work and identify gaps • Bring interdisciplinary experts on a common platform • Integration of multiple approaches is an important component of IWRM but it is a challenge • Many issues that community has a least control over it should be addressed on priority basis to gain support of community e.g. warning of drought & cyclone. Include early warning system. • Pay attentions towards the measures during IWRM which can be easily adaptable by community • Address livelihood issues and marginal community • Socio-economic issue in water use • Continue technical support after IWRM-PBS project ends • Involvement of students in the IWRM activities
11.	Prof M K Ramesh, Professor of Law, NLSIU	• Water issues required to be addressed in public domain rather than in private domain. • Various water conflict and inter-state water sharing issue need to be addressed in fast track court • Public trust can be helpful in maintenance and

		improving quality of work • Identify distinguishable feature of each PBS e.g. community participation • In IWRM activities involvement of pollution control board, disaster management centers and agricultural departments etc. can be ensured • In selected six basin studies, there should be clear cut distinction on community participation. • Chanakaya law school may help in carrying out some research work • Once action plan finalized, NIH can approach the law school, and assign the work to proceed further.
12	Prof Balaji Narsimhan, IIT Madras	• Solid waste management • There is long list of objective and technically, it is not possible to accomplish all these objectives in five years. Therefore, identify only 3-4 critical issue for each PBs to implement the IWRM plan • Focus should be on societal integration issues • Study water use efficiency in detail • Demand management is one of the most important issue • Designing of database is very important for which a core team should be formed • Ensure water rights among users • Ensure deign objectives of the project • Involvement of farmers in measurement of water resources • In IWRM activities ensure cooperation from agricultural extension department and KVK's. • There is lot of traditional wisdom for use of water, we should adopt those techniques • Suggest water conservation measures • Educate stakeholders • Carrying capacity of the basin should be kept in mind
13.	Dr Shrinivas Badiger, ATREE	• Attempt to implement scientific knowledge at grass root level • Map micro and meso level organizations in the pilot basin • In design of multi-stakeholders policy help of Dr. Pranab Chattopadhyay, University of Goa can be taken
14.	Dr Sandeep Goyal, MAPCOST	• Study of social/community system prevailing in area falling under PB • Database issues: ▪ Lot of data with different organizations but useable database is not available ▪ In database creation important issue is timeline ▪ Preparation of exhaustive list of data

		▪ Data measurement frequency and scale ▪ Standardization and codification of data ▪ Addressing of data sharing issues ▪ Monitoring and updating of data ▪ Multilingual approach in database creation ▪ Open end database management system based on the requirement • Prepare common list applicable for all basins and second basin specific lists
15.	Sh B M Murali Krishna Rao, Director, APSGWD	• Mix specific knowledge with social wisdom • Compilation of knowledge at grassroots level about IWRM • Sensitization of people in coastal areas • Involvement of women farmer in IWRM program should be insured for its success. • Appoint a communicator to transfer the technology to villagers • Local TV channel and radio can also be used for community mobilization • Hydrological data user meeting required to be organized • Common coding for storing of data • Frequency of data measurement need standardization • Optimal network design is necessary to establish GW wells and stream gauging stations
16.	Er M S Agrawal, Supdt. Engineer (Hydrology & Project Planning), WRD, GoB, Anisabad, Patna	• In 2003, backwater of Ganga at Digwar campus remained for 22 days, therefore, appropriate precautions should be taken in the installation of instruments
17.	Dr. N. C. Ghosh	• Study IWRM projects in Karnataka
18.	Dr. V. C. Goyal	• Stakeholder sensitization is vital • HELP program of UNESCO can be helpful in framing the PBS-IWRM program of NIH • Socio- economic and legal aspects can be helpful in success of PBS-IWRM program • Need of core team who can design structure of database • Legal provision is required to bind stakeholders for implementation of IWRM action plan • Financial support can be given to student engaged in the IWRM activities • Demand water management, stakeholder engagement, conflict resolution, communication and health issues, education and capacity building, local institutions, institutional framework are the major

		issues • Long term and short term objectives should be selected • Hydrological data collection activities should be carried out simultaneously • Committee of stakeholders and group discussions

Allotment of Work for next Six month: A core team of two scientists is desirable at different RCs which will be mainly responsible for the study. Other scientist at RC's and/or at different divisions at the HQ's may be involved for specific study components, depending on the requirement during different years. Based on the proceedings so far, the tentative core teams at different RC's are identified as follows and the work required to be undertaken in next six month is given in following Table:

RC/Sectt.@ Hqs	Core Team	
Sectt.@HQs	V C Goyal, Omkar Singh and R V Kale	Selection and procurement of required instruments or engagement of any private firm who can collect data from required site and at required interval for this project for the study
Belgaum	Chandra Mohan T and B Purendra	• Identification of 3-4 critical issues and define design objectives • Completed and ongoing water management programs • Database of baseline data • Preparation of thematic maps • Water demand assessments in different sectors
Jammu	Pradeep Kumar and Manish Nema	-do-
Kakinada	Y R S Rao and S V Vijay Kumar	-do-
Bhopal	T R Nayak and T Thomas	-do-
Patna	B Chakravorti and N G Pandey	-do-
Guwahati	Sanjay Sharma and Gulshan Tirkey	-do-

Study - 3

1. Title of the Study: **Action Research for Water Conservation and Management in Selected Village (s) in Hardwar District (Uttarakhand)**

2. **Study Group:**

Principal Investigators
Shri Omkar Singh, Sc. 'E', Dr. V.C. Goyal, Sc. 'F' and Dr. C.K. Jain, Sc. 'F'
Scientific/Technical Staff
Sri Yatvir Singh, SRA Staff (EHD & RMOD)

3. Type of Study: Internal

4. Nature of Study: Dissemination of R&D activities at village level

5. Date of Start: April, 2013

6. Scheduled Date of Completion March, 2015

7. Duration of the Study: 2 years

8. Study Objectives:

- Assessment of water demand, availability and water quality status in selected village (s) of the Haridwar District
- Preparation of water conservation plan for the identified village (s)
- Mass awareness activity for participatory water conservation & management

9. Statement of the Problem:

In our country, most of the traditional sources of water in villages are on the verge of disappearing/shrinking due to encroachment, siltation and water quality deterioration and witnessing severe eutrophication. The ponds located in the Haridwar District are also suffering from various hydrological problems and are at the verge of extinction, which require immediate intervention to restore for various uses. Rain water harvesting is a popular technique of developing surface water resources that can be used to provide water for livestock, domestic use and irrigation purposes. The purpose of rain water harvesting is to either augment existing water supplies or to provide water where other sources are not available. It also aims to provide water in sufficient quantity and of suitable quality for the intended use. Therefore, water conservation and its management of village ponds is essential for proper utilizing the water for beneficial use in the society. The water conservation and rain harvesting may be helpful for improving the livelihood of the people by reducing the uncertainty of human life.

10. Action Plan / Methodology:

It is proposed to assess water demand for domestic, cattle and irrigation in the identified villages and water availability for uses. Water quality and eutrophication will be assessed using standard methods for suggesting rejuvenation of the pond. The ground water level and quality will also be monitored around the villages. Accordingly, a water conservation plan for

the identified village (s) will be prepared. The mass awareness activities will also be carried out for creating awareness among the local people/school students for water conservation and management of local water sources.

11. Timeline:

S.No.	Major Activities	2013-14				2014-15			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1	Review of literature								
2	Reconnaissance survey of the study area								
3	Procurement/installation of necessary instruments								
4	Field investigations (collection of necessary statistical data at village level, water quality & water level monitoring, etc.)								
5	Analysis of data for assessment of water demand, availability at village level, water quality & eutrophication status of ponds, etc.								
6	Mass awareness activities								
7	Report preparation								

12. Objectives and achievement during last six months:

Objectives	Achievements
v. **Review of literature**	**Reviewed relevant literature**
vi. **Reconnaissance survey of the study area**	**A Reconnaissance field survey was carried out at 08 different ponds located in villages of Roorkee Tehsil (Dist. Haridwar) and obtained necessary details of the ponds.**

13. Recommendation / Suggestion: None

Recommendation / Suggestion	Action Taken
-	-

14. Analysis & Results:

A Reconnaissance field survey was carried out at 08 different ponds located in villages of Roorkee Tehsil (Dist. Haridwar) on 4.7.2013. Data on details of ponds (Latitude, Longitude, Elevation, Area), condition and prevailing economic activity of the ponds were collected.

15. **End Users / Beneficiaries of the Study:** Village Panchayats and Dist. Administration

16. **Deliverables:** Technical report and papers

17. **Major items of equipment procured:** -

18. **Lab facilities used during the study:** WQL (NIH)

19. **Data procured or generated during the study:** Data being generated

20. **Study Benefits / Impacts:** Helpful for improving the livelihood of the local people

21. **Involvement of end users/beneficiaries:** Local people

22. **Specific linkage with Institution and /or end users / beneficiaries**: Village Panchayats
23. **Shortcoming/Difficulties:** -
24. **Future Plan:** As per study plan.

Study - 4

1. **Title of the study**:

   Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India (**New Study**)

2. **Name of PI, Co-PI, & their affiliations**

   PI : Dr. V. C. Goyal, Sc F and Head, RMOD
   Co-PIs : Dr T Thomas, Sc C, GPSRC, NIH, Bhopal, MP (India)
   Dr. R. V. Kale, Sc B, RMOD
   Nodal Coordinator : Dr (Mrs) K Vijaya Lakshmi, Vice-President & Head of Innovation Systems Branch, Development Alternatives
   Dr Sandeep Goyal, Senior Scientist & Head, Resource Atlas Division, MP Council of Science & Technology
   International Collaborators: IIASA, Austria

3. **Type of study**

   Sponsored (TIFAC, Government of India funded under INDIA-IIASA programme of TIFAC)

4. **Date of start:** 1st August 2013

5. **Scheduled date of completion:** 31st January 2016 (Thirty month from start)

6. **Location map:**

   It is proposed to test the developed methodology and the DSS in Jatara sub-division of Tikamgarh district (of approx. 1,000 km^2 watershed area, covering about 170 villages), falling within the Bundelkhand region (see Fig. 1). Tikamgarh is located in the northern part of Madhya Pradesh. It lies on the Bundelkhand Plateau between the Jamni, a tributary of Betwa, and Dhasan rivers. Demographically, the total population of the district is 12,02,998, of which about 18% live in urban area and about 82% live in 963 inhabited villages in the rural area. It is administratively divided in six blocks namely Niwari, Jatara, Tikamgarh, Prithvipur, Baldeogarh and Palera. Out of the total land usage, 56% comes under net sown area; about 6% is covered by forest (of which about 71% is termed as degraded forest); and about 22% is classified as wasteland.

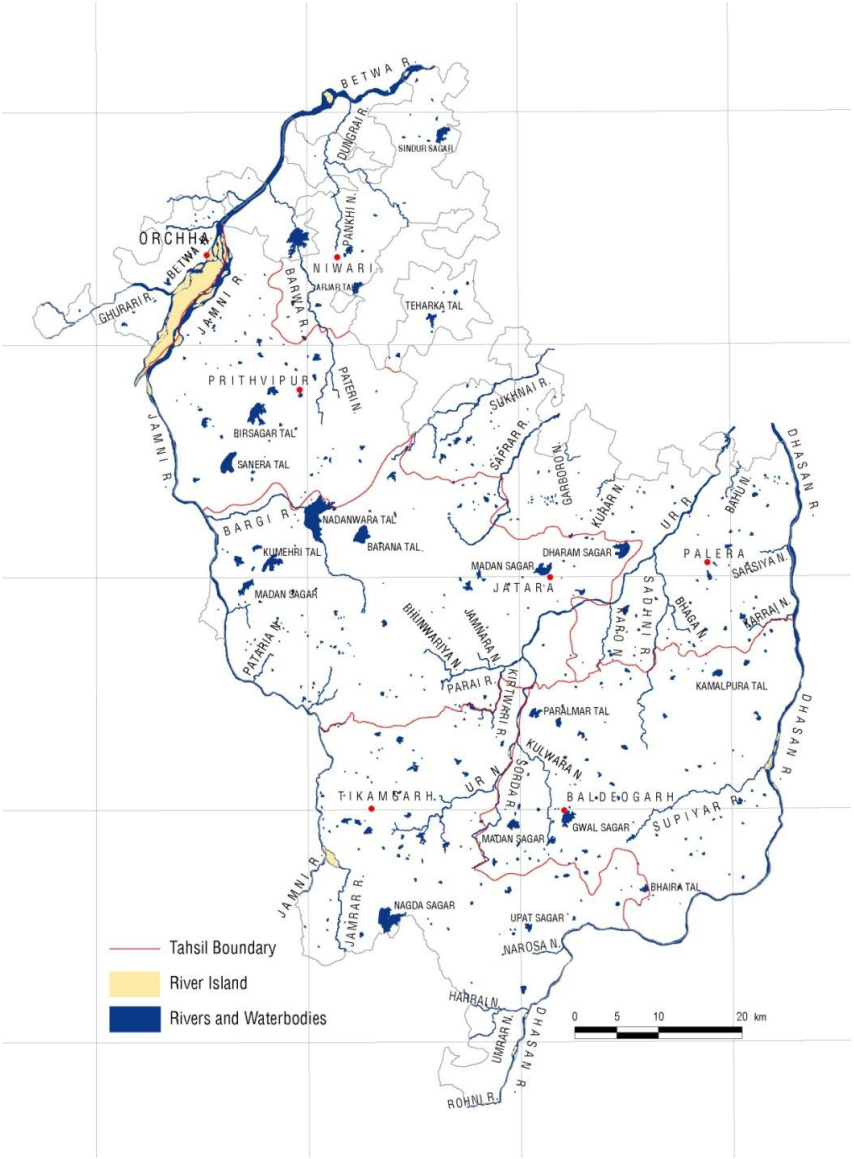


Figure 1: Location map of the proposed study area

7. Study objectives

The project essentially aims to evolve a methodology for effective water management by linking with the concept of livelihood. The methodology would be developed for a selected water-scarce area (on watershed basis), which could later be tested at other sites under similar (or different) agro-ecological conditions. The research shall lead to a water management tool (e.g. a DSS) to assist the local stakeholders in selecting and adopting appropriate water management practices on a sustainable basis. It is expected that the results of the study could provide concrete policy and management recommendations for use by the stakeholders groups.

The objectives of the project, therefore, are:

1. Development of methodologies and a decision support system (DSS) for linking the Integrated Water Resource Management (IWRM), climate change and hydrologic inputs with livelihood issues,
2. Testing the developed DSS at selected project area, and

3. Developing strategies for dissemination of the methodologies through participation of the local community and line departments.

8. Statement of the problem

A modelling framework that integrates hydrology and socio-economic aspects is a useful tool for implementing Integrated Water Resources Management (IWRM) concepts to address the sustainable development issues in a water-scarce region.

In this study, the idea is to implement the DSS in Tikamgarh district and study its impact vis-a-vis a contiguous similar area, which is not covered with the suggested interventions.

9. Methodology

A simulation based water resources planning and optimization system shall be developed and applied to address water availability and demand, water technologies and efficiency of use, allocation strategies, cost and benefits. A significant part of the effort will be devoted to the development of management scenario for the selected case study area. Three types of scenarios are considered after determining the current status of the study area: (i) business as usual (BAU), (ii) optimistic (OPT), and (iii) pessimistic (PES).

The BAU scenario assumes the continuation of existing trends and depends on the current dynamics of the study area. The OPT scenario foresees improvement in the existing policies and trends and focuses on the environment. The PES scenario assumes that population trends may increase the pressure over water use and that there is an aggravation of existing policies and trends that may have harmful effects over water. The various scenarios will be designed considering the water demand for different uses as well as water availability from different sources. The sustainable management of the gap in water demand keeping in view the economics of water use (and livelihood potential) shall be the basis for scenario design. For each scenario, sustainability indicators will be determined and then all scenarios will be compared with each other.

The involvement of stakeholders shall be made through a field survey to be conducted at the start of the study, to bring out the main water resources management decision support questions and issues which will be addressed through model simulation runs. The **categories of stakeholders** pertinent to the study area are:

- General public in urban and rural areas
- Farmers (including KVKs)
- Artisans and non-farm workers (including Skill Development Centres, vocational education centres)
- Entrepreneurs
- Technical/academic groups (including colleges, ITIs, polytechnics, engineering & management colleges) and individual experts
- Local government departments, including municipalities and Panchayats; Bundelkhand Area Development Authority; State Departments of Water Resources, Public Health Engg., Agriculture, Soil Conservation, Forest, Horticulture, etc.
- NGOs

Structurally designed questionnaires shall be used to decipher

- Environmental issues
- Water management issues
- Agricultural issues
- Wastewater reuse issues
- Physical and governance issues
- Institutional issues
- Socio-economic issues
- Livelihood issues

The proposed methodology encompasses survey research and action research. Catchment level household surveys and participatory research will be conducted to assess water-poverty linkages based on selected criteria. The participatory research will be done to understand the 'why' behind the quantitative data. The role and significance of water institutions at the community level will also be explored in order to assess their impact at the water-poverty interface. The livelihood analysis aims to provide meaningful analysis of the significance of the linkages between water and poverty, and community's acceptance to taking up possible livelihood options once water is available through IWRM efforts.

A DSS is proposed to be developed by incorporating the hydrological and socioeconomic dimensions of IWRM for the study area. This will facilitate identification and analysis of the underlying paradigm by which water resources management options are perceived, assessed, developed, adopted, and managed. Also, it will facilitate the involvement of stakeholders at every stage of activities.

For development of a community-based DSS, which will incorporate the concepts of IWRM and hydrologic inputs to link with the livelihood opportunities in the project area, the following study components are planned:

- Assessment of water demand for different uses (including livelihood)
- Estimation of water availability from different sources
- Estimation of gap in water demand (at both spatial and temporal scales)
- Planning for addressing the gap through (1) reduction in demand, (2) augmentation of supply using appropriate technology-based solutions, and (3) optimization of water management interventions keeping in view the gap in demand, water availability, livelihood opportunities and associated economics, and socio-cultural acceptance
- Generating scenarios of future water availability (with suggested interventions) and demand, and estimation of potential gap in water demand (including possible livelihood opportunities)
- Planning for addressing this potential gap in water demand for each developed scenario

The data requirement in developing a database and in carrying out various modelling analyses essentially includes <u>temporal and/or spatial data</u> on:

SN	Parameter(s)	Sources of availability	Remarks
1	Weather parameters (rainfall, air temperature, solar radiation, wind speed and direction, etc)	1. IMD 2. MAPCOST	An automated weather station (AWS) would be required to monitor additional data on continuous basis
2	Water availability: i. quantity	1. CGWB (GW)	Additional data (e.g. thru field investigations) would

	ii. quality	2. MP-WRD (SW) 3. MP-PHED/PCB	be required for detailed estimation.
3	Land use and changes in land use	MAPCOST	Additional satellite data would be required to fill the gaps with MAPCOST
4	Soil moisture profile	MP- Dept of Soil Conservation/ Agriculture	Automated electronic sensors would be installed for continuous monitoring
5	Soil fertility	MP- Dept of Soil Conservation/ Agriculture	Additional field/lab investigations may be required
6	Water demand and water use efficiency for different uses	MAPCOST may have limited water demand data	For temporal and spatial coverage, structured field surveys would be required

The developed DSS shall be implemented in the project area as a pilot scale project, with possible involvement of local Panchayats and entrepreneurs. Few technology demonstrations are planned during the project. These will help stakeholders to familiarize themselves with the concepts and techniques of water filtering, waste water treatment, water harvesting & conservation, soil moisture retention, efficient irrigation techniques, data collection & storage systems. It is expected that such demonstrations will highlight the role of technology in achieving the desired solutions and, coupled with the science communication strategies, facilitate socioeconomic acceptance of the developed DSS by the stakeholders.

The project is conceived to be executed as two components: Component-I to develop the methodology and the resulting DSS, and Component-II to test the methodology and DSS on a pilot scale in the project area. Component-I would take approximately 18-month and Component-II would need 12 months. However, preparatory work for the Component-II would start concurrently within Component-I. Involvement of local community and other stakeholders would be ensured from the beginning of the project-first to assess their felt needs and perceptions, then taking them on board during planning and development stages and, finally, during execution of the pilot scale testing. In Component-II, efforts will be made to communicate the learning of the project with policy makers. For this purpose policy briefs will be made and discussed with the policy makers.

10. **Approved action plan**

Broad responsibility of the three Indian partner organizations would be as follows:

NIH	DA	MPCOST
Water availability, water balance, DSS, development and integration of sub-models, aquifer characterization, development of impact indicators, policy briefs, water management plan, etc.	Economic survey, baseline survey, identification of livelihood options, water foot prints, capacity building, communication strategies, impact indicators, field validation of DSS, construction and management of suitable water harvesting structures	Need assessment with stakeholders, thematic maps and secondary data, identification of indicators and desired outcomes, consultative workshops, identification of appropriate technology & tech. demonstrations, , locations for water harvesting

		structures, community mobilization for pilot scale testing

Work to be executed at IIASA (Detailed work/research to be executed at IIASA along with duration)

It is expected that IIASA would provide inputs in scenario building, which is needed to investigate how supplies and demands will change in the future. Optimization of agricultural water use and income generation using different cropping patterns in the project area shall also be studied by the IIASA scientists. This will provide scenarios based on which the team together can draw policy recommendations, and in the process would build capacities of the local stakeholders.

Specifically, IIASA scientists are expected to contribute in the following subject domains:

i. conceptual modeling of agro-ecological-social-economic systems and multi-criteria decision analysis (including sustainable farm and non-farm livelihood options)
ii. scenario development (including the climate change aspects)
iii. systems modeling and optimization under risk and uncertainty
iv. data mining and assessment
v. designing of DSS structure

Timeline

Time (in months)> Activity ↓	6	12	18	24	30
Component-I (Development)					
Identification of stakeholders	■	■			
1st stakeholders' meeting (need assessment)	■	■			
Identification of indicators and desired outcomes	■	■			
Identification of DSS components	■	■			
Estimation of water availability from different sources	■	■			
Water demand assessment		■			
Estimation of gap in water demand		■			
Hydrologic Modelling (water availability, water balance, soil moisture, groundwater recharge, etc.)		■	■		
2nd stakeholders' meeting (assessment of possible solutions & DSS components)		■			
Participatory research (PRA)	■		■	■	■
Livelihood analysis	■	■			■
Identification of appropriate technology & finalization of solution thru • Water harvesting • Wastewater recycling & use • Demand management		■	■		
Assessment of economics of possible solution(s)		■			
Integration of sub-models			■		

Preparation of DSS					
Scenario building analysis					
Preparation of IWRM plan					
3rd stakeholders' meeting (finalization of IWRM plan & DSS)					
Documentation (i/c policy briefs)					
Component-II (Implementation)					
Mobilization of Panchayat and/or community for pilot scale testing					
Implementation of IWRM plan and DSS in the study area					
Plan for replication and scaling up					
Plan for post-project tracking and monitoring					
4th stakeholders' workshop (discussion of results & feedback)					
Training of users on DSS & IWRM					
Technology demonstration					
Documentation (i/c policy briefs)					

11. **List of deliverables (with delivery month)**

The following information and material needed in the policy framework for efficient water resources management in the project area will be delivered:

- Database covering water availability, water demand and gap in demand status for the project area (**M8**)
- Water situation analysis report (**M10**)
- Awareness and guidance material for the stakeholders (**M12**)
- Draft IWRM plan (**M12**)
- Decision Support System (DSS) for community-based water management and linked livelihood opportunities (**M18**)
- Technology demonstrations at stakeholders' sites (**M20**)
- Capacity building programmes for the stakeholders on IWRM (**M24**)
- Integrated Water Resource Management (IWRM) Plan for development of the project area (**M24**)
- Policy brief (**M24**)
- Plan for replication and scaling up & Plan for post-project tracking and monitoring (**M28**)
- Final project report (**M30**)

12. Suggested Post Project Activities

During the final phase of the project, it is planned to prepare plans for post-project tracking and monitoring, and for replication and scaling up of the DSS based IWRM activities in other areas. The local community and Panchayats will be trained to keep track of the physical indicators identified during the project, with assistance and technical backup of the Orchha unit of DA and MAPCOST.