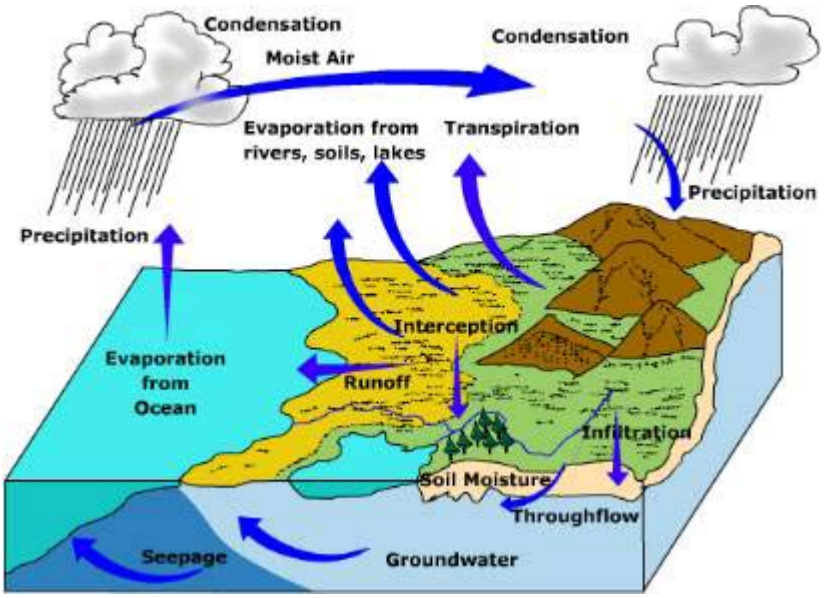
AGENDA AND AGENDA NOTES FOR THE 41th MEETING OF THE WORKING GROUP OF NIH

NOVEMBER 26-27, 2014
AT 1100 HRS



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NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

AGENDA AND AGENDA NOTES FOR THE 41st MEETING OF THE WORKING GROUP OF NIH

AGENDA ITEMS

ITEM NO. 41.1 Opening Remarks by the Chairman

ITEM NO. 41.2 Confirmation of the minutes of 40th meeting of the Working Group

The 40th meeting of the Working Group was held during June 4-5, 2014. The minutes of the meeting were circulated to all the members and invitees vide letter **No. RCMU/WG/NIH-10 dated July 7, 2014**. Er. R.K. Khanna conveyed the following suggestions: (i) Training Course on EIA (ii) Taking up EIA studies by NIH and (iii) Certifate or PG Diploma course on IWRM.

A copy of the minutes of the 40th Working Group is given in **Annexure A.**

The Working Group may please confirm the minutes.

ITEM NO.41.3 Action taken on the decisions/recommendations of the previous Working Group meeting

During the 40th 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.41.4 Presentation and discussion on the status and progress of the work programme for the year 2014-2015.

The approved Work Programme of the six Divisions of the Institute for the year 2014-15 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	03	02	**05**
Ground Water Hydrology	01	03	**04**
Hydrologic Investigation	06	09	**15**
Surface Water Hydrology	11	-	**11**
Water Resources System	11	03	**14**
RMOD	03	01	**04**
Total			**53**

During the present meeting, Division-wise progress and status of the work programme for the year 2014-15 shall be presented in detail. The Working Group may please consider the progress and status of the Work Programme for the year 2014-2015.

ITEM NO. 41.5: Any Other Item with Permission of the Chair.

ANNEXURE – A

MINUTES OF THE 40TH MEETING OF WORKING GROUP

MINUTES OF THE
40TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING JUNE 4-5, 2014

The 40th meeting of the Working Group of NIH was held at NIH, Roorkee, during June 4-5, 2014 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 40.1: 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).

The Chairman then asked Dr. Sudhir Kumar, Member-Secretary for the meeting to take up the agenda of the meeting.

ITEM No. 40.2: CONFIRMATION OF THE MINUTES OF 39TH MEETING OF THE WORKING GROUP

The 39th meeting of the Working group was held during October 21-22, 2013. The minutes of the meeting were circulated to all the members and invitees vide letter No. RMOD/39th WG/NIH/13 dated Dec, 26, 2013. As no comments were received on the circulated minutes, the minutes were confirmed.

ITEM No. 40.3: ACTION TAKEN ON THE DECISIONS/RECOMMENDATIONS OF THE PREVIOUS WORKING GROUP MEETING

Dr. Sudhir Kumar, Scientist G, gave a brief account of the actions taken on the recommendations/decisions of the 39th working group meeting.

ITEM No. 40.4: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2013-14.

The Member-Secretary requested the respective Divisional Heads to present the progress of studies carried out during 2013-14 and the proposed work programme for the year 2014-15. Accordingly, the progress of various studies and sponsored projects was presented by all Scientific Divisions on their turn during two day deliberations of the Working Group. The Division wise minutes of each study/project presented during the meeting are given below:

ENVIRONMENTAL HYDROLOGY DIVISION
Work Programme 2013-14

S.No.	Project Study	Recommendation/Suggestion
1.	Assessment of Water Quality in Hindon River Basin. Study Group: M. K. Sharma (PI), Omkar Singh, Rakesh Goyal & Dayanand DOS: 11/2011, DOC: 10/2014	Dr. S. K. Mittal appreciated the study and suggested to send the findings of the study to the concerned department so that common public should be aware of the water quality of their concerned area.
2.	Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas Study Group**:** Rajesh Singh (PI) & Dayanand **DOS: 04/2011, DOC: 03/2014**	No comments.
3.	Applications of Nanotechnology in Water Sector Study Group**:** C. K. Jain (PI), Dinesh Mohan (JNU) & Babita Sharma **DOS: 04/2013, DOC: 03/2014)**	No comments.
4.	Ground Water Quality Mapping and Surveillance for Safe Water Supply in District Hardwar and Dehradun, Uttarakhand Study Group**:** C. K. Jain (PI), Rama Mehta, S. K. Sharma, Yatveer Singh & Babita Sharma **DOS: 04/2013, DOC: 03/2014**	No comments.
5.	Water Quality Modelling using Soft Computing Techniques Study Group: Rama Mehta (PI), C. K. Jain & Anju Choudhary **DOS: 04/2013; DOC: 03/2014**	Study was appriciated by members. Director, NIH and Dr. N.B.N Prasad suggested that the developed models should be validated with latest data of water quality parameters and GIS can be used to present WQI for each sample.
6.	State-of-the-art Report on Water Quality Modelling for Each Major River and Aquifer Study Group: N. C. Ghosh (PI) & M. K. Sharma **DOS: 04/2013, DOC: 09/2013**	No comment.

7.	Environmental Flow Assessment of Hemavathi River in Karnataka Study Group: D. G. Durbude (PI) & C. K. Jain **DOS: 04/2013, DOC: 03/2015**	No comments.
8.	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier Study Group: M. K. Sharma (PI), C. K. Jain, Renoj Thayyan, Manohar Arora, Naresh Kumar, Jatin Malhotra, Rakesh Goyal & Dayanand DOS: 11/2013, DOC: 10/2016	Dr. M. K. Sharma informed that the study has been sponsored by DST and all the activities of the study will be continued under DST project. Dr. Ghosh appreciated the study and emphasised that the study will be a great contribution by NIH.

Approved Work Programme for the Year 2014-15

S.No.	Study	Study Team	Duration
	Internal Studies		
1.	Water Quality Modelling using Soft Computing Techniques (Najafgarh, Mehrauli, City and Shahadara Blocks of NCR Delhi)	Rama Mehta (PI) C. K. Jain Anju Cjoudhary	2 Year (04/14-03/16)
2.	Environmental Flow Assessment of Hemavathi River in Karnataka	D. G. Durbude (PI) C. K. Jain	2 Years (04/13-03/15)
3.	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar	Rajesh Singh (PI) C. K. Jain D. G. Durbude M. K. Sharma S. P. Rai Renoj J. Thayyan J. P. Patra	3 Years (06/14-03/17)
	Sponsored Projects		
1.	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 (04/14-03/17) DST Sponsored.
2.	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology	Vijaya Aggarwala, IITR (PI) Rama Mehta, NIH (Co-PI)	2 Years (04/14-03/16) DST Sponsored.

GROUND WATER HYDROLOGY DIVISION

Dr. N.C. Ghosh, Scientist-G and Head of the division presented an overview of studies and activities carried out by the Division during the period October – May, 2014. While presenting the technical activities carried out and progress made on different studies during last six months, he gave an account of scientific personnel available at the division and the consultancy projects pursued by the division. He informed that out of 6 R&D studies approved for the year 2013-14, two are in house studies, of which one study has been completed and for other one extension has been sought next six months, and 4 are sponsored studies, of which one study has been completed, one study will continue as its second phase, and other two studies will be completed as per the study timeline. Dr. Ghosh informed the Working Group members that the division faces acute shortage of scientific personnel to meet increasing R & D demands of various sectors.

The division has organized two training courses and one Indo-German Bilateral Workshop. These are: "Application of RS & GIS for Groundwater Modelling & Management" sponsored by GWD of Govt. of Rajasthan during 10-21 February, 2014, "Coastal Groundwater Development, Modeling and Management", under HP-II (PDS) during 3-7 March, 2014, and "Indo-German Bilateral Workshop on Science Based Master Planning for Bank Filtration in India", sponsored by Indo-German Science & Technology Centre (IGSTC), during 7-11 April, 2014 at Dresden, Germany organized jointly by NIH & HTWD, Germany. As professional scientific activities, scientists of the Division have published 15 research papers in various journals/conferences/symposia, delivered 32 lectures in various training courses and guided 08 ME/M.Tech and 07 summer trainees during the period.

The study-wise progress reported and suggestions emerged are given below.

Project Ref. Code: NIH/GWD/NIH/13-14: **Estimation of specific yield and storage coefficient of aquifers**

Dr. Surjeet Singh (PI) presented the progress of the study and various methods for the estimation of specific yield and storage coefficient. Dr. N. C. Ghosh explained the importance of precise estimation of specific yield and storage coefficient in estimation of groundwater resources. The PI also presented merits and demerits of various methods and techniques, their data requirements and a qualitative assessment on suitability of methods. The PI showed a calculation tool through spreadsheet for the estimation of specific yield and informed that the comparison of various techniques can be done using this tool, once the collection and processing of data are ready. The PI requested for an extension of six months to complete this study because of delay in the data collection. The Working Group members agreed with the extension of six months.

Project Ref. Code: NIH/GWD/NIH/13-14: **State-of-the-Art Report on Modeling of Coastal Aquifers Vulnerable to Sea Water Ingress.**

The preparation of the state-of-the-art report suggested by the Ministry of Water Resources (MoWR) has been completed. A base paper has been prepared and submitted to MoWR. WG suggested publication of metadata of the report through NIH's website.

Project Ref. Code: NIH/GWD/HP-II/10-12: **Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat.**

Dr. Anupma Sharma informed that the R & D project under HP-II (PDS) has been completed and the draft final report has been submitted to the HP-II wing of MoWR.

Dr. Sharma gave a detailed presentation on the outcome of the study including findings and recommendations. In her presentation, impact of the low rainfall in 2012 and the above average rainfall in 2013 on the water table, groundwater salinity and cropping pattern was highlighted. Hydrogeochemical analysis of the mixing of freshwater-saltwater in different seasons was explained using piper trilinear diagrams, and various indices and scatter plots. Analyses from stable isotope investigations were explained in respect of the mixing zone and groundwater recharge zones. Details pertaining to construction of fence diagram, development of conceptual model and numerical modeling exercises were presented. The problem of recurring droughts and groundwater salinity were highlighted and the conservation measures taken up by the State Government were presented. The impact of these schemes on water availability and quality was discussed using the information compiled from the socioeconomic surveys carried out in the region. Dr. Prasad and Dr. Niladri Naha enquired about the freshwater hydraulic gradient and the length of the sea coast taken up for investigation. Discussions were also held about the groundwater salinity and geological formations in the region. It was stated that long term regular monitoring needs to be taken up to check adverse impact of excessive groundwater withdrawals on groundwater quality. Members suggested that a separate presentation on the outcome of the study can be organized.

Project Ref. Code: NIH/GWD/NIH/11-14: **Managed Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)**

Dr. N. C. Ghosh presented the progress of the study. He informed that, the study as per requirement of the 'Saph Pani' project has been completed and the draft report has been submitted. Dr. Ghosh gave a brief presentation on the analysis of various components conceived in the study and on the findings. The findings included, development of semi-analytical models to estimate unsteady: (i) depth of water and (ii) groundwater recharge in/from a large water body consequent to the variable inflows and outflows acting on it, very less prevailing groundwater recharge from the Taliabandha lake in Raipur city due to the presence shale and sandstone layer beneath the lakebed, and MAR-ASTR by any engineered scheme is not feasible because the aquifer formation has massive limestone. To work out alternate plan for urban storm water and wastewater management, Dr. Ghosh requested for continue the study as its second phase. WG agreed with the proposal of the division.

Project Ref. Code: EU-sponsored Project no. 282911 : **Flow and Contaminant Transport Modeling of Riverbank Filtration.**

Divisional Head had informed that the PI of the study, Ms. Shashi Poonam Indwar, Sc.-B is on long leave on health ground; therefore, not much progress on the study has been made. He conveyed, the study will continue and will be taken up by the PI on her joining

The work programme of the division for the year 2014-15, as recommended by the Working Group, is given at annexure-I.

Annexure-I

WORK PROGRAMME OF GROUND WATER HYDROLOGY DIVISION FOR THE YEAR 2014-15

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 – 10/14) **Status**: Continuing, & extended for six months.	NIH
Sponsored				
2. 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 & expected to be completed by 30th September, 2014.	European Union under 7th - Framework Programme
3. 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 – 03/15) **Status:** Second phase will Continue	Saph Pani Project, after Sept., 2014 NIH's internal funding.
4. EU-sponsored Project no. 282911	Flow and Contaminant Transport Modeling of Riverbank Filtration	Shashi Poonam Indwar (PI), N.C. Ghosh, Anupma Sharma, Rajan Vatsa, Sanjay Mittal	2 ½ years (04/12 – 09/14) **Status:** Continuing	Saph Pani Project, after Sept., 2014 NIH's internal funding.

HYDROLOGICAL INVESTIGATIONS DIVISION

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
	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 DOS: 04/2012, DOC: 03/2014	Status: Completed There were no specific suggestions.
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 (extended upto 06/15)	Status: On-going Study The Working Group agreed to extend the study by one year, as requested by PI.
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	Status: On-going Study There were no specific suggestions.
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, B. C. Joshi, Tejdeep Singh DOS: 07/2013, DOC: 06/2015	Status: On-going Study No specific comments. PI was asked to publish the findings at the earliest.

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
5.	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes S. K. Verma (PI), S. P. Rai (Co-PI), M. S. Rao, C. P. Kumar, Mohar Singh DOS: 10/2013, DOC: 09/2015	Status: On-going Study There were no specific suggestions.
6.	Sub-marine Groundwater Discharge and Sea-water Intrusion in Coastal Aquifers of East Coast, India M. S. Rao (PI) DOS: 06/2014, DOC: 05/2016	New Study *Comment*: The Working Group appreciated the efforts of NIH in taking up Radon measurements based technology to map submarine groundwater discharge and seawater intrusion. *Suggestions*: Although the project submitted is very ambitious but not workable in the present submitted form due to (i) the collaborative partners not yet finalized, (ii) major funding required to accomplish the objectives, and (iii) time lines not fixed. It was therefore suggested to prepare the project document after conducting a brain storming session and then to submit the project to DST for funding. Till it gets approved by DST, this may be taken up as a pilot project using NIH funds for a limited time and limited coast length. For the pilot project, the title may be modified and re-submitted.
7.	Monitoring Isotopes in Air Moisture in Parts of Himalayas (Himachal Pradesh & Uttarakhand) for investigating the Cloud Condensation M. S. Rao (PI), C. P. Kumar, Gopal Krishan DOS: 06/2014, DOC: 05/2016	New Study There were no specific suggestions.

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
SPONSORED PROJECTS		
8.	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 DOS: 07/2007, DOC: 12/2013	Status: Completed There were no specific suggestions.
9.	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 DOS: 10/2008, DOC: 03/2014	Status: Completed There were no specific suggestions.
10.	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 DOS: 10/2008, DOC: 03/2014	Status: Completed There were no specific suggestions.
11.	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: 08/2015	Status: On-going Study There were no specific suggestions.

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
12.	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 DOS: 06/2012, DOC: 05/2015	Status: On-going Study There were no specific suggestions.
13.	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: 09/2014	Status: On-going Study There were no specific suggestions.
14.	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	Status: On-going Study There were no specific suggestions.
15.	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains Sudhir Kumar (PI), S. P. Rai, S. D. Khobragade, C. K. Jain, P. K. Garg DOS: 05/2013, DOC: 04/2015	Status: On-going Study No specific comments. PI was asked to publish the findings at the earliest.
CONSULTANCY PROJECTS		

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
16.	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 DOS: 07/2011, DOC: 06/2013	Status: Project completed
17.	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)	Status: Pre-dredging part of Project completed
18.	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, J. V. Tyagi, Surjeet Singh, S. D. Khobragade, R. K. Jaiswal, P. K. Garg DOS: 04/2013, DOC: 09/2013	Status: Project completed
19.	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur Sudhir Kumar (PI) DOS: 05/2013, DOC: 04/2016	Status: On-going Project

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
20.	Impact Assessment of Ash Pond on the Groundwater Quality in the Surrounding Villages of NTPC Simhadri through Stable Isotopic Studies Sudhir Kumar (PI) DOS: 07/2013, DOC: 06/2014	Status: On-going Project
21.	Identification of Source and Locations of Leakage/Seepage from Kaushalya Dam, Haryana S. P. Rai (PI) DOS: 08/2013, DOC: 01/2014	Status: Project completed

WORK PROGRAM OF HYDROLOGICAL INVESTIGATIONS DIVISION FOR THE YEAR 2013-2014

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**

S. No.	Study	Team	Duration/ Status
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 B. C. Joshi (CGWB, Lucknow) Tejdeep Singh (CGWB, Chandigarh)	2 years (07/13-06/15) New Study
5	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in 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			
6	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 6 months (07/07–12/13) Continuing Study
7	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 6 months (10/08-03/14) Continuing Study
8	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
9	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

S. No.	Study	Team	Duration/ Status
10	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
11	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 8 months (02/13-09/14) Continuing Study
12	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
13	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Sudhir Kumar (PI) S. P. Rai S. D. Khobragade C. K. Jain P. K. Garg	2 years (05/13-04/15) New Study
CONSULTANCY PROJECTS			
14	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
15	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
16	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 J. V. Tyagi Surjeet Singh S. D. Khobragade R. K. Jaiswal P. K. Garg	6 months (04/13-09/13) New Study
17	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur	Sudhir Kumar (PI)	3 years (05/13-04/16) New Study
18	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
19	Identification of Source and Locations of Leakage/Seepage from Kaushalya Dam, Haryana	S. P. Rai (PI)	6 months (08/13-01/14) New Study

WORK PROGRAM OF HYDROLOGICAL INVESTIGATIONS DIVISION FOR THE YEAR 2014-2015

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**3 years** **(07/12-06/15)** **Continuing Study**
2	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) **Continuing Study**

S. No.	Study	Team	Duration/ Status
3	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 B. C. Joshi (CGWB, Lucknow) Tejdeep Singh (CGWB, Chandigarh)	2 years (07/13-06/15) Continuing Study
4	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in 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) Continuing Study
5	Sub-marine Groundwater Discharge and Sea-water Intrusion in Coastal Aquifers of East Coast, India	M. S. Rao (PI)	2 years (06/14-05/16) New Study
6	Monitoring Isotopes in Air Moisture in Parts of Himalayas (Himachal Pradesh & Uttarakhand) for investigating the Cloud Condensation	M. S. Rao (PI) C. P. Kumar Gopal Krishan	2 years (06/14-05/16) New Study
SPONSORED PROJECTS			
7	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
8	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

S. No.	Study	Team	Duration/ Status
9	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
10	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 8 months (02/13-09/14) Continuing Study
11	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Sudhir Kumar (PI) S. P. Rai S. D. Khobragade C. K. Jain P. K. Garg	2 years (05/13-04/15) Continuing Study
CONSULTANCY PROJECTS			
12	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur	Sudhir Kumar (PI)	3 years (05/13-04/16) Continuing Study
13	Impact Assessment of Ash Pond on the Groundwater Quality in the Surrounding Villages of NTPC Simhdri through Stable Isotopic Studies	Sudhir Kumar (PI)	1 year (07/13-06/14) Continuing Study
14	Isotopic Characterization of Groundwater of District Raigarh, Chhattisgarh	S. P. Rai (PI)	6 months (04/14-09/14) New Study
15	Hydrogeological Studies for Ash Pond of 2 X 525 MW Maithon Power Limited and an Abandoned Coal Mine, District Dhanbad, Jharkhand	Sudhir Kumar (PI)	3 months (06/14-08/14) New Study

SURFACE WATER HYDROLOGY DIVISION

Dr. Rakesh Kumar, Scientist, "G" and Head, Surface Water Hydrology Division presented a summary of the studies being carried out by Surface Water Hydrology Division along with number of research papers published/accepted for publication/ communicated as well as other research and technical activities carried out by the division. The progress of studies was then presented by the respective P.Is. of the studies. The details are as under.

1. HYDROLOGICAL STUDIES FOR UPPER NARMADA BASIN

Mr. Jagadish Prasad Patra, PI of the study presented the completed study. The objectives with brief methodology are presented. Major work carried out including data collection, river cross-section survey, water availability analysis, rainfall-runoff analysis, rainfall and flood frequency analysis, estimation of PMF, Dam break flood simulation etc were discussed in details during the presentation. Finally, the developed flood inundation maps for various return periods flood and dram break flood are also presented. The Member of the working group appreciated the results and interaction with the dam authority during the study as the results might be helpful to them in preparing emergency action plan etc.

2. STATE-OF-THE-ART REPORT ON SOIL EROSION AND SEDIMENT TRANSPORT MODELLING

Dr. J.V. Tyagi presented the study and 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 was entrusted to NIH. In the light of this background, he explained that the objective of the state-of-the-art report is to provide a resource on soil erosion and sediment transport modelling for the use of potential model developers and model users to guide their erosion modelling applications at catchment scale. Dr. Tyagi further informed that the report has been completed and explained the salient contents of the report. There were no comments on the study.

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

Mrs Archana Sarkar, PI of the study presented the background, objectives, methodology and results of the completed study. Mrs Sarkar informed that the 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 for the country. She informed the house that Hydrological modeling studies in Brahmaputra basin" is one of the thrust areas of "12thfurther 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 presented various ANN models developed for the study, i.e., three groups of

ANN models for daily sediment yield modelling and four groups of ANN models for both ten-daily as well as monthly sediment yield modelling. Within each group, three models each have been considered based on lagged variables. Mrs Sarkar informed that as per the results obtained, it was evident that daily ANN models performed best when past time step suspended sediment

Concentration data was considered as input but in case of monthly models, the performance was best with only rainfall and temperature as the input data. Therefore, it was concluded from the study that daily ANN models are useful for short term forecasting whereas monthly ANN models are more suitable for studying the impact of climate change on sediment flux. Working group members noted the results of the study. Five Year Plan" of the institute.

4. SEDIMENTATION STUDIES FOR PONG RESERVOIR, HIMACHAL PRADESH (2012-2015)

Dr. A. R. Senthil kumar, PI of the project, presented the objectives, methodology and progress of the study for the period from November 2013 to May 2014 and overall progress 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 presented the uncertainty analysis of the rainfall and flow volume of 10%, 50% and 90% dependable series for future 25, 50, 75 and 100 years. He also presented the status of determination of bandwidth of optimal weights of ANN model by boots trap method. Shri R K Khanna, CWC suggested to have contacts with officers of CWC as they are dealing with the reservoir sedimentation.

5. STUDY OF HYDRO-METEOROLOGICAL DROUGHTS FOR CHITRAKOOT DISTRICT OF BUNDELKHAND REGION IN INDIA

Dr Rakesh Kumar, Head, Surface Water Hydrology Division reported the progress of studies in brief and invited Dr R.P. Pandey, PI of the project, to presented details of activities carried out in respect of ongoing study for the period after last working group meeting. Dr Pandey reported that the study site had faces acute drinking water shortages during summer months and this problem was very 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 the data processing & analysis and preparation of base maps have been completed. He further informed that the 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, probability distribution of annual and seasonal rainfall, dryspell analysis and estimation of supplemental water requirement for dry-spell periods for kharif season crops have been completed and same was 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, it was informed that the same methodology has been incorporated in the DSS (P) for identification of onset of drought events and

quantification of their severity. The results of the method applications were demonstrated in the meeting. The PI informed that the flow measurement records 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. The River Tons is flowing adjoining to the Pasuni river and have nearly identical topographic features. It was reported that the study area has been grouped in to different clusters depending on the physiography, location, potential source of water supply and population. It was informed that the interim Report of this study would be submitted in June 2014.

6. QUANTITATIVE ASSESSMENT OF UNCERTAINTIES IN RIVER DISCHARGE ESTIMATION

Dr. Sanjay Kumar presented the study on "Quantitative assessment of uncertainties in river discharge estimation". He explained the background and objectives of the study and mentioned that study is a part of the systemic review of uncertainty clause of the ISO 9123 document. He explained the methodology based on ISO documents GUM (Guide to the expression of uncertainty in measurement), HUG (Hydrometric uncertainty guidance) and presented the progress made in the study. He mentioned that a NWIP (New Work Implementation Plan) has been submitted along with a working draft of the uncertainly clause of the above ISO document. He informed that draft document is uploaded on the ISO web site for comments and review from experts.

7. EVALUATION AND MODELING OF HYDROLOGICAL SUPPORT SYSTEM FOR WATERSHEDS OF GARHWAL, UTTARAKHAND HILLS

Dr. Avinash Agarwal also presented the study entitled "Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills". It was informed that this study has been submitted to DST for possible funding. Some prelim works on classification and relative classification of spring by four methods were presented. Springshed delineation and the area of springshed for the springs were identified and presented. Working group accepted the study progress.

8. ESTIMATION OF WATER BALANCES FOR INTEGRATED WATER RESOURCES MANAGEMENT IN YERRAKALVA PILOT BASIN, A.P.

Dr. J.V. Tyagi proposed the new study for the year 2014-15 under the thrust area of Integrated Water Resources Management (IWRM). It was informed that NIH has taken up Pilot Basin Studies (PBS) for IWRM in Yerrakalva river basin in coastal Andhra Pradesh under 12^{th} five-year plan program. The program involves detailed studies on various components of the hydrologic cycle including water balance study of the basin. The components of water balance of a basin are influenced by climate, the physical characteristics of the basin such as morphology, land use and soil. Therefore, understanding the relationship between these physical parameters and hydrological components are very essential for integrated water resources management and long term sustainability of water resources in the basin. Dr. Tyagi explained that the SWAT, one of the most recent models developed by the USDA,

will be used to analyse and quantify the water balance of the Yerrakalva river basin. The model has been chosen as SWAT is an integrated river basin scale, physically based, continuous-time, long-term simulation, distributed model. Also, its suitability to different parts of the world has been well established. The hydrologic cycle as simulated by SWAT is based on the water balance equation. Model outputs all water balance components (surface runoff, evaporation, lateral flow, recharge, percolation etc.) at the level of each sub-watershed and are available at daily, monthly or annual time steps. The study was approved by the working group.

9. STATUS REPORT ON "IMPACT OF ANTHROPOGENIC AND CLIMATE CHANGE ON SEDIMENT LOAD OF RIVERS"

Mrs Archana Sarkar, PI of the study presented the background, objectives, methodology and expected deliverables of the new study. Mrs Sarkar informed that the sediment load of a river represents a key component of its hydrology, and in turn exerts an important influence on its aquatic ecology, its morphology and the exploitation of its water resources. She further informed the house that changes in the sediment loads of rivers can therefore have wide-ranging environmental and social and economic implications. She also informed about the growing evidence (reported by various authors for different rivers of the world) that the sediment loads of many rivers of the world, especially Asian rivers have changed significantly in recent years due to many reasons, including anthropogenic as well as climate change impact). Mrs Sarkar emphasized on the need to carry out a comprehensive up to date review of all such studies and prepare a status report. Working Group members noted the objectives of the study and appreciated the proposal. Dr. Sharad K. Jain suggested that Dr. Jaivir Tyagi has recently completed a status report on, "Soil erosion and sediment transport modelling" and the PI may consult Dr. Tyagi for carrying out the proposed study.

10. STUDY OF RAINFALL PATTERNS AND COMPARISON OF RAINFALL DATA FROM DIFFERENT SOURCES FOR UTTARAKHAND STATE

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 Uttarakhand State, often referred to as the "Land of the Gods" due to the many holy Hindu temples and pilgrimage centres found throughout the state which observed a massive flood disaster in June 2013. Mrs Sarkar informed the house that a good knowledge of local rainfall-regime is crucial for planning and management of domestic, urban as well as industrial water use, irrigation and crop practices besides forecasting and management of extreme events like floods and droughts. She further informed that in view of the recent flood disaster in the Uttarakhand state, it becomes all the more important to carry out a scientific analysis of the rainfall regime of the region. Mrs Sarkar also informed that a comparative accuracy assessment of various data sources of rainfall viz, Rain gauges, satellite sensors (TRMM), and high resolution gridded re-analysis rainfall (APHRODITE) is of prime importance as the rainfall data from these data sources are further provided to hydrological models to produce forecasts. Mrs Sarkar proposed to carry out the trend analysis of historical rainfall data by parametric and non-parametric methods. Mrs Sarkar informed that this study would conclude by providing discussion about the accuracy of TRMM satellite rainfall data and APHRODITE rainfall data with respect

to the observed rain gauge data. Dr Sharad Jain enquired if similar comparison study has been carried out for Himalayan region and Mrs Sarkar informed that such study has been carried out for Nepal Himalayas. Working group members noted the objectives, methodology and expected deliverables of the study and appreciated the proposal.

11. MONITORING AND MODELLING OF STREAMFLOW FOR THE GANGOTRI GLACIER

Dr. Manohar Arora, PI of the study presented the study. He explained that the objectives of the study are: continuous observations of meteorological, hydrological and suspended sediment data for the melt season to determine monthly and seasonal specific water and sediment yield from the study glacier; to study the melt water storage and drainage characteristics of the glacier and to simulate daily streamflow using a conceptual hydrological model using observed meteorological and hydrological data; modeling the role of glacier in catchment runoff variation; modeling the catchment runoff variation under different climatic scenarios.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. The third step is to model role of glacier in catchment runoff variation and catchment runoff variation under different scenarios. The Department of Science and Technology has sponsored this study. This is the first year and the investigations were started on 17th May 2014. 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. The results of the study will be disseminated by DST.

12. EFFECT OF CLIMATE CHANGE ON EVAPORATION AT POINT SCALE

Mr. Digambar Singh, Sc B, PI of the study proposed the new study for duration of three year with objectives of to develop evaporation model by empirical and soft computing techniques; to downscale the data of temperature, rainfall and humidity from GCM model; to determine the effect of climate variables on evaporation by using the downscaled data. It is informed that the Multiple Linear regression (MLR) and soft computing techniques would be applied to model the evaporation with rainfall, temperature and humidity as input vectors. The weather generators, considering the future carbon emissions, radiation and effects of green house gases, have been developed to generate the time series by fitting a distribution to the times series and by using the properties of distribution of the times series. The different scenarios of climatic conditions may be obtained from SDSM (Statistical DownScaling Model) from UK/PRECIS from IITM, Pune. The best models developed by soft computing techniques to simulate the evaporation from historical values of rainfall, maximum and minimum temperature and humidity at the site can be utilized to generate the evaporation from the generated values of rainfall and maximum and minimum temperature and humidity for different climatic scenarios as mentioned above. The falling and rising values of evaporation from the different climate scenarios would give an idea to the official dealing with the planning of cropping pattern.

13. HYDROLOGICAL MODELLING OF BRAHMANI BAITARANI RIVER BASIN USING EWATER SOURCE PLATFORM

Mr. Jagadish Prasad Patra, PI of the study proposed the new study for duration of three year. The objectives, present state of art, brief description of study area and methodologies are presented. The members enquired possibility of external funding for the project. It is informed that the work has been assigned by Ministry to NIH and at present the model is provided to NIH from Ministry and no other cost is to be funded by NIH.

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

Dr. Surjeet Singh (Co-PI) presented the progress of the study as Dr. Lohani was on leave. He presented the rainfall-runoff modeling using Mike 11 NAM model for the Arpa sub-basin and the status of data collection from the Chhattisgarh State as well as the future plan of action of the study. No comments/suggestions were made**.**

WORK PROGRAMME OF SURFACE WATER HYDROLOGY DIVISION FOR THE YEAR 2014-15

S. No. & Ref. Code	Title	Study Team	Duration
Internal Studies			
1. NIH/SWD/NIH/11-14	Hydrological studies for upper Narmada basin.	J. P. Patra Rakesh Kumar Pankaj Mani T. R. Sapra	3 Years (April 2011 to March 2014)
2. NIH/SWHD/NIH/13-14	State-of-the-Art Report on Soil Erosion and Sediment Transport Modelling	J.V. Tyagi	1 year (April 2013 to March 2014)
3. NIH/SWD/NIH/13-14	Suspended Sediment Flux Modelling in the largest sub-basin of Brahmaputra	Archana Sarkar Rakesh Kumar	1 year (April 2013 to March 2014)
4. NIH/SWD/NIH/12-15	Sedimentation Studies for Pong Reservoir, Himachal Pradesh	A. R. Senthil kumar Manohar Arora Suhas D Khobragade Avinash Agarwal Sanjay Jain	3 years (April 2012 to March 2015)
5. NIH/SWD/NIH/12-15	Study Of Hydro-Meteorological Droughts For Chitrakoot Bundelkhand Region In India	R.P. Pandey	3 years (April 2012 to March 2015)
6. NIH/SWD/NIH/13-16	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3 Years (April 2013 to March 2016)

7. NIH/SWD/NIH/13-16	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills.	Avinash Agarwal Manohar Arora RK Nema	3 Years (November 2013 to October 2016)
8. NIH/SWD/NIH/14-15	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P.	J.V.Tyagi YRS Rao,	1 year (April 2014 to March 2015)
9. NIH/SWD/NIH/14-15	Status Report on "Impact of Anthropogenic and Climate Change on Sediment Load of Rivers"	Archana Sarkar	1 year (April 2014 to March 2015)
10. NIH/SWD/NIH/14-16	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State	Archana Sarkar N.K. Bhatnagar Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar	2 years (April 2014 to March 2016)
11. NIH/SWD/NIH/14-17	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	3years (May 2014 to March 2017)
12. NIH/SWD/NIH/14-17	Effect of climate change on evaporation at point scale	Digambar Singh A. R. Senthil kumar Manohar Arora	3years (June 2014 to March 2017)
13. NIH/SWD/NIH/14-17	Hydrological Modelling of Brahmani Baitarani River Basin using eWater Source Platform	J.P.Patra Rakesh Kumar Pankaj Mani	3years (April 2014 to March 2017)
14. 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)

WATER RESOURCES SYSTEM DIVISION

The head of the division, Dr. Sharad K Jain, Scientist G made a brief presentation about the various research activities carried out by the division since the last working group meeting. He also informed about the scientific strength of the division, completed and ongoing internal research studies, sponsored and consultancy studies taken up by the division, and the trainings courses organized by the scientists of the division. After that PI of each study presented their studies. The highlights of these are as follows.

Title: Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range

Dr. Thayyen presented this completed internal study. He informed that the study has revealed the sharp vertical hydrological gradient in the cold-arid system. He

emphasised that the Temperature-Lapse rate is the most critical parameter in the snow melt runoff model. Generally standard environmental lapse rate ranging from 6.5 to 8.9 ^{0}C per 1000 m is used for snow melt modeling. The study found that the Slope Environmental Lapse Rate (SELR) have significant seasonal variation linked with the moisture influx to the region. During summer months, SELR between 3500 to 4700 m a.s.l was consistently ranged between 10 to 15 ^{0}C per 1000 m espousing the cold-arid conditions. It was informed that the runoff modeling has been performed using the WinSRM model.

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

The study was presented by Sh. L. N. Thakural. The objectives of the study are to create the database for Rainfall and Temperature variables for the Himalayan region and to carry out statistical analysis to detect trend and variability in these variables in the Himalayan region, India. The parametric (Linear regression) and non-parametric (Mann-Kendall and Sen's estimator of Slope) approaches are being used to determine the trends in the time series data of these meteorological variables. Results of analysis for the hydro meteorological data in the Western Himalayan region covering the states of Jammu & Kashmir and Himachal Pradesh along with the results of trend and variability carried out for the observational sites in the western Himalayan region were presented. There were no specific comments.

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

Dr. M. K. Goel (MKG) presented the progress for the study. MKG informed that since the last working group, efforts have been made to make some modifications in model methodology which included: a) incorporation of relationships for approximation of EAC tables for a reservoir, b) incorporation of rule-curve based operation analysis for reservoir systems, c) incorporation of hydropower simulation analysis, and d) simplification of groundwater representation in the model. MKG informed that various existing options in the model have been preserved and new modifications have been added as additional options. A draft report detailing various modifications has been submitted. Further, some similar softwares are under review so that relevant possible options could be incorporated in the existing model. MKG informed that though the framework of WINDOWS interface has been finalized, the detailed forms for various options would be developed after completing the planned modifications. Mr. Kishore Kumar (KK) asked whether a User Manual would be prepared for the software. MKG informed that a detailed manual would be prepared and help files would be attached for various modules for easiness in model application.

Title: Web GIS based snow cover information system for Indus basin.

The study was presented by Co-PI Shri L. N. Thakural. The objective of the study is to develop methodology for snow cover mapping using MODIS data and publish snow cover information for Indus basin on web/intranet using GIS server. In this study, snow cover was mapped using MODIS MOD09A2 data for year 2008 in ILWIS and QGIS software for the seven sub-basins of Indus. The downloaded data were in

HDF format and having sinusoidal map projection. Sub basin wise statistics was computed for snow cover. The statistics of the snow cover for the entire sub basin was presented. Sh. Kishore Kumar enquired when will this information be loaded on the web? Mrs. Deepa Chalisgaonkar replied that presently it is working on LAN of the institute. It will be installed on the website of the institute after the completion of the study.

Title: Assessment of Water Footprint of the National Capital Territory (NCT) of India

Mrs. Deepa presented the study. She informed that the water footprint of an area is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of that area. She informed that the methodology used in this study is largely based on earlier studies supported by Water Footprint Network, the previous methodologies are integrated and upgraded where ever possible. Sri R K Khanna enquired whether the tanker water supply has been considered or not. Mrs Deepa replied that all the sources of water supply by DJB have been considered. Shri Kamal Kishore and Shri N K Shama mentioned that the study would be useful. Working group noted the progress of the study.

Title: Impact of climate and land use change on floods of various return periods (TR)

Dr. Sanjay Kumar presented the status of the on-going study on topic impact of climate and land use change on floods of various return periods. He explained the objectives, methodology and the results achieved so far. Dr. Sanjay Kumar presented the NWP model and its merit over GCM and also discussed the percentage deviations in floods of various return periods for two different climatic scenarios, i.e. one increasing the highest flood series by twenty percent and in other decreasing at the lowest flood series. He presented briefly the expected outcome, results in regards to the objectives, the uncertainty band in return period flood and the land use in Mahanadi basin. There were no questions from the members.

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

The status of the study was presented by Shri P.K. Mishra. He informed about the progress made in the study since inception as well as during last six months. Shri Mishra informed that trend for three variables viz. rainfall, temperature (mean, minimum, maximum), and potential evapotranspiration (PET) have been investigated. He presented the results and inferences drawn from the trend analysis of the rainfall data, temperature data, and potential evapotranspiration data for the KBK region. Dr. Sreemati Gupta suggested to explore the spatial (district-wise) correlation for the rainfall, temperature and PET as per the trend emerging from the study. Shri Mishra also informed that major data has already been collected from different sources/ agencies. He further informed that the digitization work has been completed for the SOI toposheets (21 nos.) and the soil map (04 nos.).

Title: Glacier change and glacier runoff variation in the upper Satluj river basin

Dr. Sanjay K Jain, presented the background and objectives of the study as well as the progress made so far. He informed that three sub-basins of Upper Satluj basin have been taken for this study. The maps of these sub-basins have been prepared in GIS. Glacier change detection in two-sub basins have been carried out using temporal satellite data while for the third sub-basin (Spiti), glacier change detection is in progress. The meteorological and discharge data have been collected. Er. N K Sharma asked about the reasons of glacier retreat. Dr. Jain said that analysis of temperature and snow water equivalent data is under progress and then correlation between these with glacier change will be studied. He informed that as per the literature survey the main reason of retreat is temperature rise.

Title: Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj

The progress of the study was presented by Mr. Manish Kumar Nema. The presentation contained the background of the study, study area details, data availability, methodology to be used and some preliminary results of the rainfall trends over the Lower Satluj region. The results support the rising trends of the rainfall in the study area in annual and monsoon season with a significant level of 95%. No specific comments and suggests were made pertaining to study.

SPONSORED STUDIES

Title: Glaciological studies of Phuche Glacier, Ladakh Range.

The progress of the study was presented by Dr Renoj J Thayyen. He explained about the importance of the response of small glaciers in the Cold-Arid climate system of the Trans-Himalaya to the prevailing climate and huge knowledge gap in our understanding of factors influencing glacier response to the climate change and its consequences. He then focused on the winter and summer mass balance of Phuche and Khardung glaciers which are under study. He informed the group that during the four years of study (2010-2013), Phuche glacier experienced two slightly positive mass balance years interspersed with two significant negative mass balance years. Khadung glacier experienced consistent mass loss with a remarkable cumulative mass loss of (-) 2690 mm w.e. during these four years.

NEW PROPOSALS

Title: Hydrological modeling of a part of Satluj basin using SWAT Model

Mr. P. K. Agarwal presented the new study before the working group. No comments were received. However, Dr. Sharad K. Jain pointed out that Shri Manish Nema is already working on the same basin and has collected considerable data for the same. To avoid duplicity of data collection, Shri Manish Nema will share the data, maps and other information available with him and will be a part of this study. The project proposal was approved by the working group.

Title: Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra

In the absence of the PI, Mr D. S. Rathore, Dr M. K. Goel made a presentation of this new study. He informed that in this study, it is planned to use MIKE HYDRO systems and DSS 4.0 software for detailed analysis of water resources in Upper Bhima basin up to Ujjani dam. He informed that detailed database of the study area was developed in HP-II project and now it is envisaged to use the database with new software system with following objectives: 1) Rainfall- runoff modeling and estimation of water availability in the basin, 2) Multi-reservoir operation in the basin for project complexes, 3) Drought prediction 4) Water quality modeling in the basin, 5) Conjunctive use operation in command area and 6) River basin simulation for climatic change scenarios. In response to some queries from Dr N.B.N. Prasad and Mr Kishore Kumar, MKG informed that in addition to the available analytical capabilities of the present DSS system, various modules can be written in the DSS in scripting language in accordance with the analysis requirement. Such algorithms would be developed, if required, for the analysis in the present study.

Title: Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh

As the second phase of the project entitled “Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range” Dr Renoj J Thayyen presented a new research study. During the presentation he talked about the objectives, study area, social implications of the projects. He informed that the major objective of the study is to understand the cryospheric systems dynamics through a Benchmark glacier catchment strategy that has already implemented in the upper Ganglass catchment. He informed that this study will use the database available and upgrading it along with following objectives: 1) To improve the understanding of the climate forcing on cold-arid cryospheric system, 2) To improve the understanding of the melt water generation process and the role of permafrost, 3) To improve the understanding of various runoff components under different surface snow conditions, 4) To study the temporal variations in isotopic characteristics of winter base flow and summer flow of the perennial reach.

The approved work plan for the division for 2014-15 is given in Table 1.

WORK PROGRAMME FOR THE YEAR 2014-2015

S. N.	Title	Study Team	Duration	Funding (Rs. Lakhs)
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)	NIH
2.	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Sharad K. Jain Deepa Chalisgaonkar Prabhash K. Mishra	2 Years (04/13-03/15)	NIH
3.	Web GIS based snow cover information system for the Indus Basin	D. S. Rathore Deepa Chalisgaonkar L. N. Thakural	2 Years (04/13-03/15)	NIH

		Tanvear Ahmed		
4.	Assessment of Water Footprint of the National Capital Territory (NCT) of India	Deepa Chalisgaonkar Sharad K. Jain M. K. Nema P. K. Mishra	2 Years (04/13-03/15)	NIH
5.	Impact of Climate and Land Use Change on Floods of Various Return Periods	P. K. Bhunya Sanjay Kumar D S Rathore	2 Years (04/13-03/15)	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 (04/13-03/15)	NIH
7.	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain Sharad K. Jain Renoj J. Theyyan	2.5 Years (10/13-03/16)	NIH
8.	Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj	M. K. Nema Sharad K. Jain	2 Years (11/13-10/15)	NIH (11.34)
Sponsored Studies				
1.	Glaciological studies of Phuche Glacier, Ladakh Range, India	Renoj J. Theyyan M K Goel S P Rai	5 Years 1/10-12/14	DST (56.00)
2.	Ganga River Basin Environment Management Plan	Sharad K Jain N. C. Ghosh Sanjay K. Jain M. K. Goel	2 Years 07/12-06/14	IIT Kanpur (12.00)
3.	Assessment of Environmental flow for Himalayan River	Sharad K. Jain Pradeep Kumar P. K. Agarwal P. K. Mishra	1 Year 07/14-07/15	MOES (9.95) (Funds are expected shortly)
Proposed New Internal Studies				
1.	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain M. K. Goel Sanjay K. Jain MK Nema Tanvear Ahmed	2 -3/4 Years (06/14-3/17)	NIH (23.00)
2.	Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra	D. S. Rathore M. K. Goel, R.P. Pandey Sanjay Kumar Surjeet Singh	2 years (07/14-06/16)	NIH (34.00)
3.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Theyyan S P Rai	3 years (04/14-03/17)	NIH (20.00)

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)
WORK PROGRAMME FOR YEAR 2014-2015

S.N.	Title of Project/Study, Study Team, Start/Completion Dates	Status and Recommendations/Suggestions
1.	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs (**Joint Study)** **NIH HQs:** V C Goyal (Leader), Omkar Singh, R V Kale **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu, RC-Kakinada, RC-Sagar, CFMS-Guwahati, CFMS-Patna DOS: Apr 2012; DOC: Mar 2015	**Status:** Inception report (2013-14) submitted. Chairman suggested that this study may be re-structured during 2014-15 in view of priority of the MOWR.
2.	Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, J.V. Tyagi and Sanjay K. Jain DOS: Apr 2013; DOC: March 2015	**Status:**Interim Report (2013-14) submitted. Dr N B Narasimha Prasad wanted to know about basis for per capita water requirement used for the rural areas in this study. The PI responded that the data used in the study is based on the norms of Ministry of Drinking Water & Sanitation (GoI).
3.	Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India (Sponsored under INDIA-IIASA Programme of TIFAC) **Team (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 **International Collaborators:** IIASA, Austria DOS: Aug 2013; DOC: Jan 2016	**Status:** on-going study No specific comments.
4.	Participatory development of structure for IWRM Framework in identified sub-basins under Pilot Basin Studies (PBS) program **(New Study)** **Team:** V C Goyal (PI), Omkar Singh and R V Kale DOS: July 2014 DOC: June 2015	The Chairman suggested that this study will be finalized after discussion with PI of the study.
5.	Customization of WEAP model for application in Ur river watershed in Tikamgarh district of	**Status:** New Study No specific comments.

	Bundelkhand region. **(Under TIFAC Project)** **Team:** R V Kale (PI), T Thomas- RC Bhopal, Jyoti Patil, Rajesh Agarwal DOS: Apr 2014 DOC: Sep 2015	

Sponsored Projects

1. Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India, **Funded by TIFAC, Government of India under INDIA-IIASA Programme of TIFAC**
   Period: Aug 2013-Dec 2016 (30 months) Budget: Rs 56.64 lakh
   Team from NIH:
   V C Goyal (PI), T Thomas (Co-PI), R V Kale (Co-PI)
   Nodal Coordinators from other partners:
   Dr (Mrs) K Vijaya Lakshmi, DA, New Delhi
   Dr Sandeep Goyal, MAPCOST, Govt. of MP (India)
   International Collaborators: IIASA, Austria

2. Development of a DSS for Hydrology and Watershed Management in Neeranchal Project, **To be funded by Dept. of Land Resources (GoI) under a World Bank supported project**
   Period: Jun/Jul 2014-May 2019 Budget: Rs 30 Crore approx.
   Partners: NIH; IIT Delhi; WTC Delhi; NRSC Hyderabad

The Working Group noted the progress of the studies undertaken by all divisions. Further the members requested NIH to take up the following items in future.

- NIH should conduct training courses on EIA and IWRM.
- A comprehensive data base should be prepared.
- Institute should study the rock-water and soil-water chemistry
- The Institute should prepare the brochure reflecting its capabilities of taking up the various consultancy projects. The brochure should be uploaded on Institute website and widely circulated to various governmental and nongovernmental organizations.

Dr. Sudhir Kumar, Scientist G, HI Division 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 40th WG meeting

1.	Er. R.D. Singh, Director, NIH	Chairman
2.	Dr. S.K. Jain, Sc. G & Head WRS Division, NIH	Member
3.	Dr.(Mrs) Sreemati Gupta, Supdt. Geologist, GSI, Faridabad	Member
4.	Dr. Kishore Kumar, NIC, New Delhi	Member
5.	Dr. S.K. Bartarya, WIHG, Dehradun	Member
6.	Dr. S.K. Mittal, CSIO, Chandigarh	Member
7.	Dr. N.B. Narasimha Prasad, Ex. Dir., CWDRM, Kozhikode	Member
8.	Sh. Niladri Naha, State Water Invest. Dir., Kolkata	Member
9.	Er. R K Khanna, Chief Engineer (Retd.), CWC, New Delhi	Member
10.	Sh. N.K. Sharma, SE, IRI, Roorkee	Member
11.	Dr. N.C. Ghosh, Sc. G & Head GWH Division, NIH	Member
12.	Dr. Rakesh Kumar, Sc.G & Head SWH Division, NIH	Member
13.	Dr. C.K. Jain, Sc. G & Head EH Division, NIH	Member
14.	Sh. C.P. Kumar, Sc. F & Head HI Division, NIH	Member

Scientists from National Institute of Hydrology, Roorkee

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

ANNEXURE – B

Division-wise Work Programme

ENVIRONMENTAL HYDROLOGY DIVISION

Scientific Manpower

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

Work Programme for the Year 2014-15

S.No.	Study	Study Team	Duration
	Internal Studies		
1.	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) C. K. Jain	2 Years (05/14-03/16)
2.	Environmental Flow Assessment of Hemavathi River in Karnataka	D. G. Durbude (PI)	2 years (04/13-03/15)
3.	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar	Rajesh Singh (PI) C. K. Jain M. K. Sharma S. P. Rai Renoj J. Thayyan J. P. Patra	3 Years (07/14-06/17)
	Sponsored Projects		
1.	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 (04/14-03/17) Sponsored by DST, New Delhi
2.	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology	Vijaya Aggarwala, IITR (PI) Rama Mehta, NIH (Co-PI)	2 Years (04/14-03/16) Sponsored by DST, New Delhi
	Consultancy Project		
1.	Water Safety Impact Assessment through Sanitary Improvement of India Mark 2 Hand Pumps in Moradabad Division, Uttar Pradesh	C. K. Jain (PI) Babita Sharma Rakesh Goyal Daya Nand	6 Months (10/14 – 03/15) Sponsored by: UNICEF Office for Uttar Pradesh Amount: 12 Lakh

Training Course Organized / To be Organized

S.No.	Topic	Duration	Venue
1.	Water Quality and its Management (Jointly with CSMRS)	1-5 Sep. 2014	Roorkee
2.	Monitoring and Analysis of Non-point Source Pollution (NPS) – Agriculture in a Riverine System (Sponsored by CPCB)	13-15 Oct. 2014	Roorkee
3.	Advanced Instrumentation Technique and Preventive Maintenance (Sponsored by CPCB)	8-10 Dec. 2014	Roorkee
4.	Hands on Advanced Instruments of Water Quality Testing (Sponsored by WQAA/MoWR, RD & GR)	12-16 Jan. 2014	Roorkee

Study – 1

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. 'G'
Scientific/Technical Staff Ms. Anju Chowdhary, SRA

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of start: May 2014

6. Scheduled date of completion: March 2016

7. Duration of the Study: Two years

8. Study Objectives:

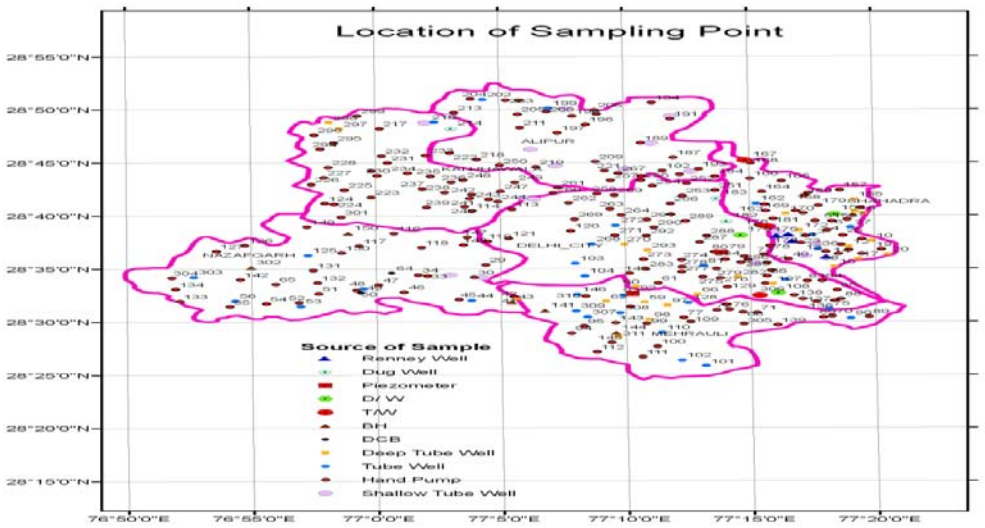
To develop the models for assessment of the quality of water with its quality parameters for Najafgarh, Mehrauli, Delhi City and Shahdara blocks of NCR using conventional and soft computing techniques.

9. Statement of the Problem:

The quality of ground water within National Capital Region (NCR) Delhi varies from place to place along with the depth of water table. The kind and concentration of dissolved salts depend on their source and nature of sub surface environment.

Various methods are discussed in literature on drinking water quality criteria and decision-making. But most of the reports on the water quality revealed that deterministic approach in decision making by comparing values of parameters of water quality with prescribed limits provided by different regulatory bodies is used without considering uncertainties involved at various steps throughout the entire procedure. To overcome the difficulties of complex ground water quality there has been a need to develop techniques that can help to find meaningful solutions. Soft computing techniques are relatively new emerging techniques used in hydrologic and water resources systems. Fuzzy logic technique used in uncertainties in water resources system arises not only due to randomness of hydrological variable but also due to imprecision, subjectivity, vagueness associated with decision making and lack of adequate data. Such uncertainties are best addressed through fuzzy logic technique. Therefore, new emerging techniques as Neuro-Fuzzy techniques and ANN are frequently used to develop the models. Fuzzy_Mamdani Inference technique has been used during the study.

The NCT of Delhi having Six administrative blocks namely Alipur, Kanjhawala, Najafgharh, Mehrauli, City and Shahdhara. The ground water sampling locations have been depicted as below (Fig. 1):



Water quality Modeling for two administrative blocks viz. Alipur and Kanjhawala have been done with three different techniques and results have been analyzed with empirical techniques for Water Quality Index during previous study (2013-2014). Now during this study, models have to be developed using all three techniques for rest four blocks viz. Najafgarh, Mehrauli, City and Shahadara of NCR region.

10. Approved Action Plan / Methodology:

Water quality indices (WQI) 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 have been employed to calculate the water quality index:

- Empirical Method
- Soft Computing Techniques (SCT)-Mamdani_ Fuzzy Inference System (M_FIS)
- Canadian Water Quality Guidelines

11. Timeline:

Activities	2014-15				2015-16			
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Data collection for four administrative blocks								
Model Development with application of Empirical method & CCME-WQI technique for all four blocks.								
Model Development with application of soft computing method as M_FIS technique.								
Testing, evaluation, and								

comparison with conventional method.								
Result analysis & Report writing								

12. Objectives and achievement during last six months:

Objectives	Achievements
Model development with application of soft computing methods	Three models (One models with Empirical method, One models with CCME_WQIG and One models with Fuzzy Inference Technique) have been developed for City block.
Testing, evaluation and comparison with conventional method.	Results via Fuzzy model have been compared with conventional method and Canadian formula (CCME) For Delhi city block. Comparative results have shown through graphs and performance indices.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken

14. Analysis & Results:

- The ground water quality of the City Block has been assessed with all three methods as Empirical method, CCME Water Quality Index guidelines (CCME_WQI) and Fuzzy Inference method.
- Comparative graphs with all results have been drawn.

15. End Users / Beneficiaries of the study: Hydrologist, Public, & Water agencies working for NCR region

16. Deliverables: Technical report, research papers and manual

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:

Measurable indicators	Achievements
Model development for block Delhi City with new emerging techniques	Completed for one block
Solution of identified problem	Completed for one block

21. Involvement of end users/beneficiaries: Local people of the NCR region.

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

23. Shortcoming/Difficulties: No

24. Future Plan: Models will be developed for remaining three administrative blocks of NCR.

Study -2

1. Title of the Study: Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar

2. Study Group:

Project Investigator Dr. Rajesh Singh, Sc. 'B'
Project Co-investigator Dr. C. K. Jain, Sc. 'G', EHD Dr. M. K. Sharma, Sc. 'D', EHD Dr. S. P. Rai, Sc. 'E', HID Dr. Renoj J. Thayyan, Sc. 'D', WRSD Dr. J. P. Patra, Sc. 'B', SWHD
Scientific/Technical Staff 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: July 2014

6. Scheduled date of completion: June 2017

7. Duration of the Study: 3 Years

8. Study Objectives:

i) Catchment characterization affecting river water quality
ii) River water quality assessment for different designated uses
iii) Decipher the different sources of solutes controlling the river water quality
iv) Nutrient loading due to anthropogenic activity
v) CO_2 consumption during chemical weathering

9. Statement of the Problem:

The purity and sanctity of Himalayan Rivers is challenged now by the technological development and growing financial strength of the nation. Construction of plethora of roads along the fragile mountain slopes facilitated movement of more men and material to the fragile Himalaya. Tourist activities in this region have increased many folds in recent years. More land is being brought under cultivation and more and more fertilisers and pesticides are being used to manage the crop productivity. As a by product of these developmental activities, the pristine rivers of the Himalaya are getting polluted more and more. Moreover, the increase in temperature and CO_2 in atmosphere will results in change in the pattern of chemical weathering and transport of solute through these rivers.

Therefore, there is a need for water quality assessment of Himalayan Rivers to understand the multifold impact of urbanization, tourist influx, and climate change on water quality of rivers.

10. Approved Action Plan / Methodology:

i) Collection of river water, suspended sediments, and bed sediment samples from Gangotri to Haridwar on monthly basis.
ii) Analysis of river water samples for physico-chemical, isotopic, and bacteriological composition.
iii) Analysis of river bed sediments for elemental and mineral composition.
iv) Processing the data to understand the contamination of water and consumption of CO_2 during the weathering process.

11. Timeline:

Sr. No.	Major Activities	2014-15			2015-16				2016-17				17-18
		2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.
1	Literature Survey												
2	Field Investigation												
3	Sample Collection and Analysis												
4	Data Collection and Interpretation												
5	Status Report												
6	Interim Report												
7	Final Report												

12. Objectives and achievement during last six months:

Objectives	Achievements
Literature Survey	• Literature survey completed.
Field investigation, Sample Collection and Analysis	• Field investigation completed. • Samples collected during June and September. Analysis is under progress.

13. **Recommendation / Suggestion:** Nil

Recommendation / Suggestion	Action Taken

14. Analysis & Results:

- Geo-spatial map showing sampling locations prepared.
- Pre and post monsoon samples collected.
- Physico-chemical, bacteriological and isotopic (δO^{18} & δD) analysis of pre-monsoon samples completed.

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

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
River water quality assessment	Under progress
Nutrient loading	Under 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:**

- Sampling and analysis of river water, suspended sediments and bed sediments on bi-monthly basis.
- Processing the data to understand the contamination of water and consumption of CO_2 during the weathering process.

Study -3

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. 'D'
Co-Investigator Dr. C. K. Jain, Sc. 'G' Dr. Renoj Thayyan, Sc. 'D' Dr. Manohar Arora, Sc. 'D'
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: Sponsored project by DST, New Delhi, **Budget: Rs 30.60 lacs**

4. Nature of Study: Applied Research

5. Date of start: April 2014

6. Scheduled date of completion: March 2017

7. Duration of the Study: 3 Years

8. Study Objectives:

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

9. Statement of the 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. Approved Action Plan/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

11. Timeline:

Activity	2014-15				2015-16				2016-17			
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Literature survey												
Reconnaissance Survey												
Collection of SS and meltwater samples												
Chemical analysis of SS and meltwater samples												
Geochemical analysis of SS												
Open and close system study												
Dissolution experiments of glacial meltwater -SS interaction												
Interim Report Writing												
Final Report Writing												

12. Objectives and achievement during last six months:

Objectives	Achievements
Reconnaissance Survey	Carried out reconnaissance survey of Gangotri Glacier from 26th June to 2nd July, 2014 and fixed the sites at Gomukh, Bhojwasa and Gangotri for collection of meltwater and suspended sediment samples.
Collection of SS and melt water samples	Meltwater and suspended sediment samples were collected from Gomukh, Bhojwasa and Gangotri from 28 June to 16 October 2014.
Chemical analysis of SS and melt water samples	Insitu parameters like Air Temperature, Water Temperature, pH and EC were measured. Chemical analysis of meltwater sample is under progress.

13. Recommendation / Suggestion: None

Recommendation / Suggestion	Action Taken

14. Analysis & Results:

i) Carried out reconnaissance survey of Gangotri Glacier from 26th June to 2nd July, 2014 and fixed the sites at Gomukh, Bhojwasa and Gangotri for collection of meltwater and suspended sediment samples.
ii) Meltwater and suspended sediment samples from Gomukh, Bhojwasa and Gangotri were collected during 28th June to 16th October 2014 as details given below:

a) Collect the water and suspended sediment samples from Bhagirathi River at Gangotri just before Bathing Ghat near Gangotri Temple and measured air and water temperature at 8.30 A.M. and 5.30 P.M. every Sunday on weekly basis.
b) Collected the water and suspended sediment samples and measured air and water temperature once every Sunday on weekly basis from the selected site at Gomukh (Snout).
c) Collect the water and suspended sediment samples from Bhagirathi River at Bhojwasa and measured air and water temperature at 8.30 A.M. and 5.30 P.M. every Sunday on weekly basis. Hourly samples were also collected on 15th and 30th of every month.

iii) Air Temperature, Water Temperature, pH and EC were measured at the time of sampling. Chemical analysis of collected meltwater sample is under progress.

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

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: i) Low Temperature pH Meter ii) Low Temperature EC Meter iii) Temperature probe with data logging iv) Deep Freezer

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

19. Data procured or generated during the study: Hydro-chemical data of Gangotri Glacier

20. Study Benefits / Impacts:

- Study of low temperature ionic enrichment during interaction between glacial sediment and melt water especially for glaciers with huge supraglacial debris cover.
- Ionic enrichment dynamics of meltwater-glacial sediment interaction under open and close system.
- Provide a strong basis extending studies of solute variability and sediment and pollutant loading further downstream.

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:

- Chemical analysis of meltwater sample and suspended sediment
- Processing of hydro-chemical data

GROUND WATER HYDROLOGY DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2014-15

S. No.	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 – 10/14) **Status** : **Completed**, Need 4 months extension for developing the outreach material	NIH
Sponsored & HP-II Projects				
2 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 (10/ 11-9/14) **Status: Completed** successfully with a Final Conference organized at New Delhi, 18-19 September, 2014.	EU sponsored collaborative R & D Project.
3. 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:** Saph Pani Project part completed. An extension for one year (up to March, 2015) was approved in last WG.	Saph Pani Project/ extended study will continue as internal funding
4.	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:** Seeking extension for 1 year, i.e., up to 09/15.	Extended period will continue as internal funding
Proposed New Study				
5.	Ganges Aquifer management for Ecosystems services (GAMES)	Sharad Jain (PI), N.C. Ghosh, Sudhir Kumar, Sanjay Jain, M.K. Goel, Anupma Sharma, Surjeet Singh	1 year (01/06 – 31/05) **Status**: in progress.	IWMI, Hyderabad
6.	Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin	Anupma Sharma (PI) N. C. Ghosh & other NIH study team member Collaborating Institute; IIT Roorkee, CED	3 years (December, 2014 – Nov., 2017) Status : New	Initially by NIH, later on by sponsoring agency.

Status of outreach activities carried out during the year 2014-2015

1. Organized one International Conference titled ”*Natural Treatment Systems for Safe and Sustainable Water Supply in India: Results from Saph Pani Project*” at New Delhi during 18-19 September, 2014 together with RMOD and FHNW, Switzerland.. Dr. N. C. Ghosh delivered two presentations, the one on “Future steps for bank filtration in India” and the other one on “Feasibility of MAR in Raipur city area”, in the Conference.

2. Scientists guided **3** Summer interns students of College of Agriculture Engineering, Acharya N. G. Ranga Agricultural University, Baptla Guntur, A.P. (2 students) and SRM University, Chennai (1 student).

3. Two scientists (Dr. N.C. Ghosh and Mr. Sumant Kumar) attended the ‘Saph Pani’ biannual review meeting at Orleans, France (12-13 May, 2014) and a training course on “*Natural Treatment Systems*” during 15-16 May, 2014 at IHE-UNESCO, The Netherlands. Dr. N. C. Ghosh delivered a lecture on “Managed Aquifer Recharge in India” in the training course at the Netherlands.

4. Scientists published/accepted 5 papers in international journals, **4** in national journals, **5** papers in international Conferences, **1** eBooks (Scientific Essay & Academic Paper) published by GRIN Publishing, Germany and **2** book chapters.

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

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

Date of Start: April 01, 2013
Scheduled Date of Completion: October. 31, 2014
Location Map: Site specific data and information.

Approved action plan:

- Exhaustive literature review.
- Compilation on various methods of specific yield and storage coefficient estimation 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: Compilation on various methods, their data requirements, merits and demerits and categorization of various methods, prioritization of methods.

13-18 months: Development of interface for the selection of methods and computation of specific yield and storage coefficient under different field conditions.

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. • Merits and demerits of various methods their data requirements. • Assessment on the suitability of various methods. • Data collection. • An interim report prepared.
Preparation of a state-of-the-art report on estimation of specific yield and storage coefficient.	• Development of interface for the selection of suitable methods and computation of specific yield and storage coefficient under different field conditions.

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

Nil.

Analysis and Results:

1. Comprehensive review of literature.
2. Merits and demerits of various methods and their categorization.
3. Assessment on data requirements of various methods.
4. Assessment and prioritization on suitability of various methods.
5. Selection of suitable methods and computation of specific yield and storage coefficient under different field conditions.

List of deliverables:

- Compilation on various methods for computation of specific yield and storage coefficient.
- Computer-based interface for the selection of suitable methods and computation of specific yield and storage coefficient under different field conditions.

Data procured and generated:

- Soil profile details and texture, groundwater levels, groundwater recharge and draft, some lithologs, etc. were collected.

Future Plan:

It has been planned to develop a web-enabling interface of the developed code and to upload it to NIH's website. The developed code will be provided to RMOD for dissemination of the software. The user manual and the report will be submitted by 31st December,2014.

2. PROJECT REFERENCE CODE: NIH/GWD/INT/14-15

Title of the study: **Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin**

Study team:

- Coordinator : Dr. N. C. Ghosh, Scientist-G, GWH Div.
- PI : Dr. Anupma Sharma, Scientist-D, GWH Div.
- Study Group : Groundwater Hydrology Division in collaboration with study group from IIT Roorkee

Type of study (sponsored/consultancy/referred/internal): Internal (at present)

Date of start: December 2014

Duration of study: Three years

Study objectives:

1. Numerical modeling for optimal management of surface water and groundwater in Yamuna-Hindon inter-basin
2. Strategies for groundwater management associated with climate variability events
3. Assessment of surface water and groundwater quality degradation due to disposal of municipal and industrial effluents and impact on groundwater pumpage

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

Severe water quality degradation issues have affected the domestic and irrigation water supply in the fertile Yamuna-Hindon inter-basin. A detailed project proposal in collaboration with Dept. of Civil Engg., IIT Roorkee is being submitted for possible funding with a view to develop strategies for conjunctive management of water resources in the region.

3. PROJECT REFERENCE CODE: EU-sponsored Project (GA no. 282911)

Title: Saph Pani- Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India

The Project "Saph Pani" has been completed successfully with organization of an International Conference titled "Natural Treatment Systems for Safe and Sustainable Water Supply in India: Results from Saph Pani Project" at New Delhi during 18-18 September, 2014.

NIH has completed satisfactorily all its tasks related to WP1, WP2, WP5, & WP7, which are listed below:

Work Package (WP) number	WP Title
WP 1	Bank Filtration in Urban areas under varying Pollutant loads and flood situation
WP 2	Managed Aquifer Recharge and Soil Aquifer Treatment
WP 5	Modelling and system design
WP 7	Training and Dissemination

The study areas for R & Ds in which NIH was involved are

For WP 1: Haridwar, and Baseline data collection from existing RBF sites in India and modelling.

For WP 2: Managed aquifer recharge and soil aquifer treatment – Urban storm water management in Raipur.

For WP 5: Based on the baseline data to be collected from WP1, & WP2, involvement in modelling of the respective site.

Presently, NIH is working with other consortium partners to develop different assigned chapters for the "Saph Pani Hand Book" to be published by The International Water Association (IWA) Publishing.

Out of the allocated budget of 2,42,044 €, NIH could claim a sum of 2,36,681 € against potential expenditures of 2,37,930 € (INR 1,77,70,184).

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

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

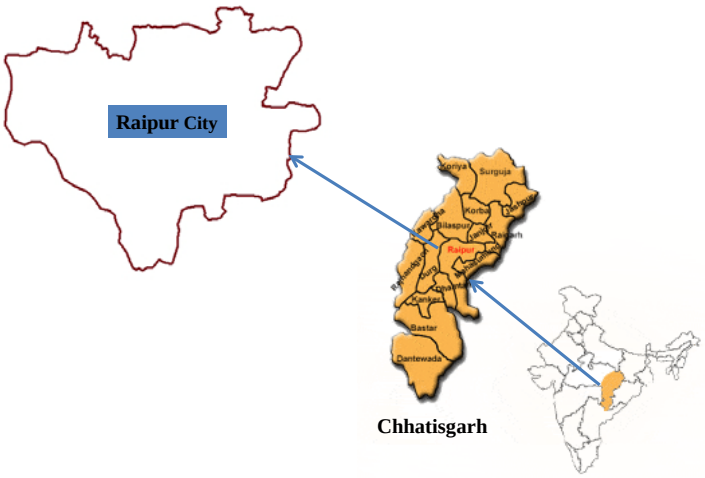
Team members : 1) Mr. Sumant Kumar- PI 2) Mr. Rajan Vatsa- Co-PI
3) Dr. N.C Ghosh 4) Mr. C. P Kumar
5) Dr. Surjeet Singh 6) Mr. Sanjay Mittal
7) Dr. R.P. Singh

Type of study : Internal study under the framework of "Saph Pani" Project.

Date of Start : 1st April, 2011

Scheduled Date of Completion : 31st March, 2014 (Extension- 1 year)

Location Map Raipur Municipal boundary forms the study area which lies between 21° 10'and 21° 21' N latitudes and 81° 32' to 81° 44'E longitudes. Raipur is the capital of state Chhattisgarh.



Objectives

1) To identify the potential recharge sites for groundwater (GW) resources 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.
4) To develop a conjunctive use solution of surface water and groundwater resources.

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 (Completed)
To model & analyze aquifer response due to the recharge from the identified potential recharge site	The Semi-analytical model is developed to estimate recharge (Completed).
To manage the augmented GW resources for subsequent potential uses	It is estimated that recharge from selected recharge site (Teliabandha lake) is very less due to hydro geological condition. Therefore, we are attempting to study other prominent Talabs to make best possible uses of surface water.

Analysis and Results

A comprehensive analysis of hydrological, hydrogeological and water quality aspects of Teliabandha Lake and its catchment have been carried out. The analysis of hydrological components included: rainfall-runoff modelling, evaporation rate and lake water quality assessment. The hydrogeological components included: aquifer characterization, aquifer parameters estimation, groundwater level and quality analysis. The groundwater recharge rates for variable inflows and outflows to/from the lake have been quantified by developing a semi-analytical model integrating Hantush's (1967) analytical expression for water table rise due to recharge from a rectangular spreading basin into the basic water balance equation of the lake. The basic concept followed in estimating the unsteady groundwater recharge consequent from variable inflows and outflows is the water balance of the lake is shown in Figure 1. The groundwater recharge rate has been found very low varying between 3.75 mm/day and 4.82 mm/day for depth of water in the lake ranging between 2.5 m and 3.36 m. The geological formations for the site posses constraints of thick limestone formation- a limiting factor for MAR-ASTR proposition. The lake water quality data analysis show that the turbidity and chemical oxygen demand exceed the permissible limits mentioned in BIS (10500-2012) guidelines for drinking water. In addition to this the presence of fecal coliform and total coliform has been found in the lake water.

Various aspects of Teliabandha lake as mentioned above have been studied under Saph Pani project for which the report is submitted to saph pani consortium. Since, MAR & ASTR is not feasible due to hydrogeological conditions and bad water quality of Teliabandha Lake. Therefore, it is proposed to study the other prominent lakes for management of surface water. The reduced level of lake bed has been measured using DGPS. To assess the suitability of surface water and groundwater for different purposes, water samples were collected from both the sources. Using the lake bed R.L critical path for the connectivity of different water sources, is in progress. The chemical water quality data have been analyzed, classified and studied for their suitability for drinking and irrigation purposes.

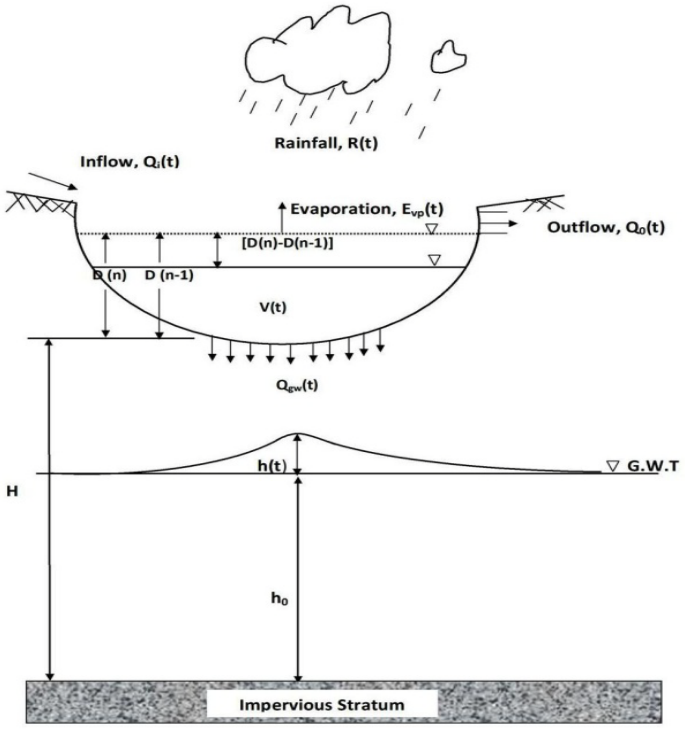


Figure 1: Schematic diagram for Water Balance of Lake

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

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

Study Group: Mrs. Shashi Poonam Indwar (PI), Dr. N.C. Ghosh (Co-PI), Dr. Anupma Sharma, Sc-E, Mr. Rajan Vatsa, Sc-B, Mr. Sanjay Mittal, S.R.A

Type of study: Under the Work Package-I of 'Saph Pani' Project

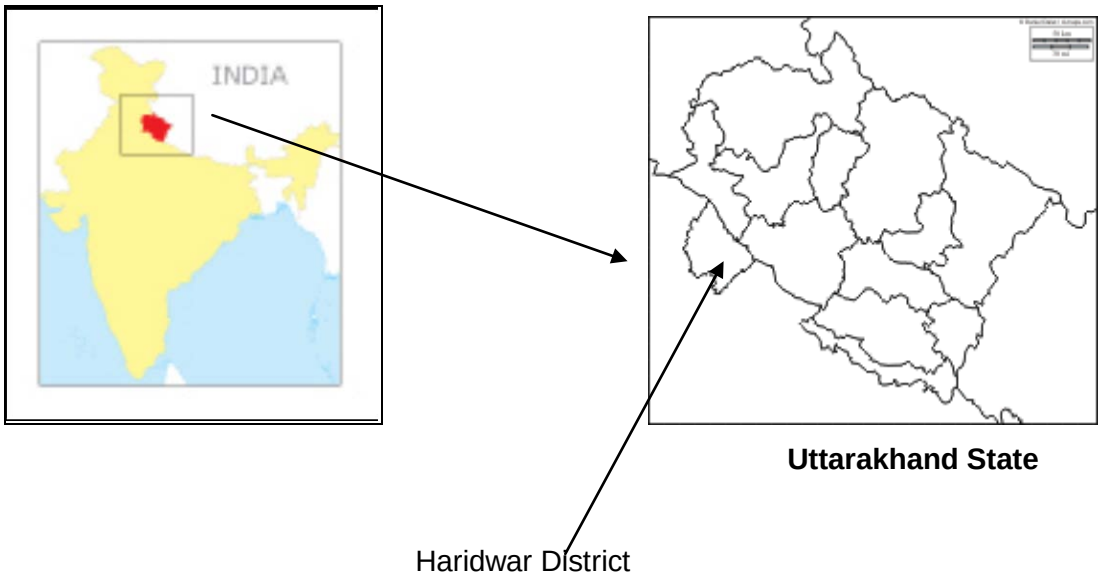
Nature of study: Technology or technique development

Date of start: 1st April 2012

Scheduled date of completion: October 2014

Location map

India



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.

Statement of the problem:

Uttarakhand Jal Sansthan (UJS) has installed 22 nos. of Infiltration wells along the bank of the river Ganga. These wells are operated to supply drinking water to the nearby areas in the Haridwar Cit. During monsoon period as post treatment sodium hypochloride is used in the well as disinfectant chemical. These wells are located at varying distances (50-495m) from the river centerline and have been constructed at varying depths (7-10m) below ground surface. It is considered that due to bank filtrations & mixing of nearby groundwater,

those wells are producing good quality of water, to the extent of permissible limit, and removing the pathogenic loads satisfactorily.

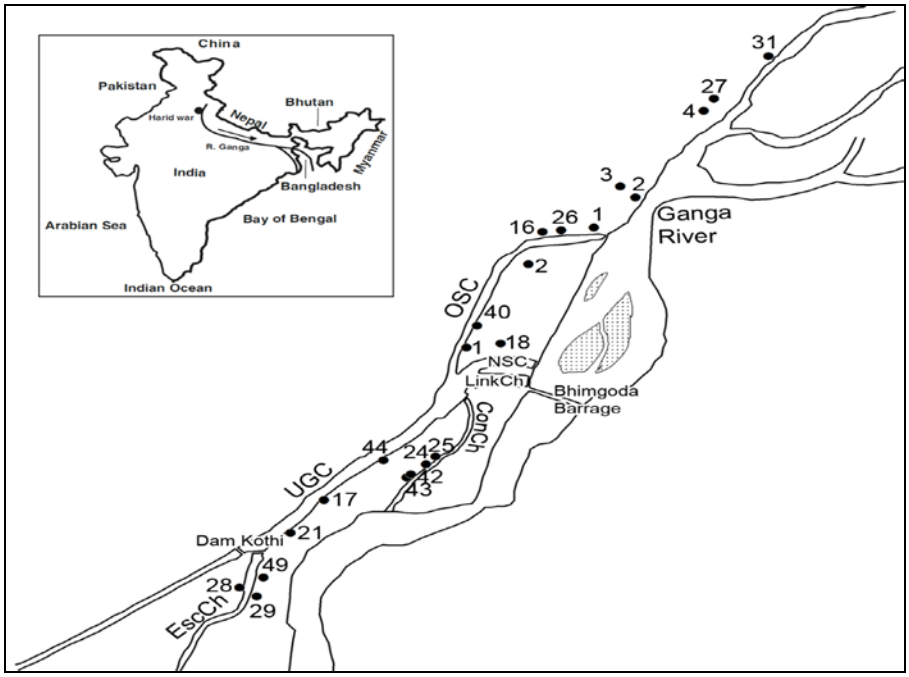


Figure1.Study area of the riverbank filtration site with 22 Infiltration wells in Haridwar, India

The present study is intended to analyze and model the flow paths, travel times of bank filtrate water from the river to the well for the given hydrogeological setups and varying flow conditions in the river. It would further be attempted to develop a flow and contaminant transport model based on the existing scenario.

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 the year (2012-2014)

Review Literature	Completed
Reconnaissance Survey of study sites	Completed
Data collection and base data analysis	Completed
Analysis of field data(Conceptualization of the problem, model setup, model data preparation)	Completed
Contaminant Transport Modeling & analysis	Under progress

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 has been collected and assimilation of various other data related to flow modeling is complete. • The Conceptual framework for the flow model has been prepared. Steady-state modelling of bank filtrate travel-time and flow path is complete.
• To model and evaluate removal performance of organic pollutants, coliform bacteria and other pathogens by Bank Filtration.	• Will be followed up after first objective.

Analysis and Results:

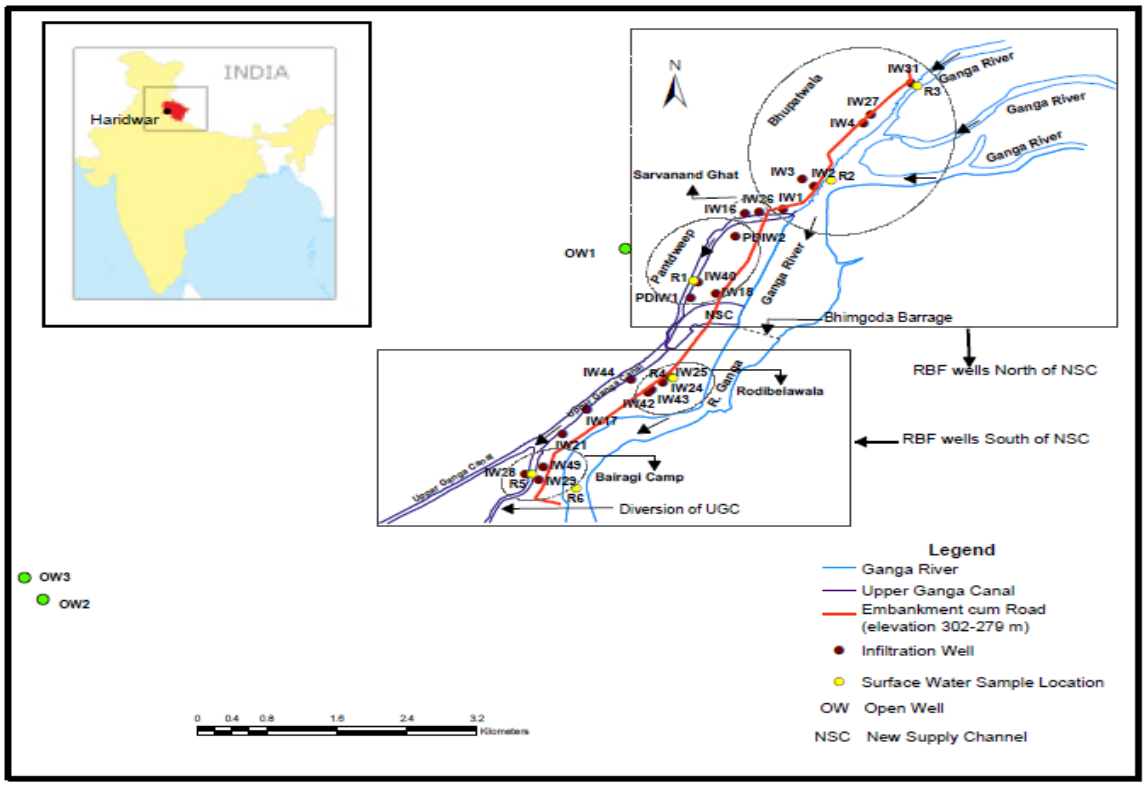


Figure 1: Location of 22 Infiltration wells along the river Ganga and the Upper Ganga Canal system in Haridwar –Water samples collection site of groundwater, surface water and infiltration wells.

Analysis of Results: To determine the water quality improvement in riverbank filtrate, samples from groundwater, surface water and RBF wells water were collected once a month. Comparison of water quality parameters for surface groundwater and Infiltration well

enabled assessment of natural treatment process of riverbank filtrate water. Analysis of major ions such as Na^{2+}, K+, $Ca^{2+,}$ Mg^{2+} SO_4^{2-} NO_3 enabled to assess the mineralization process of water during the subsurface passage. Concentration graph shows the major ions present in surface, groundwater and infiltration well for the site Bhupatwala, Pantdweep and Beragi Camp area.

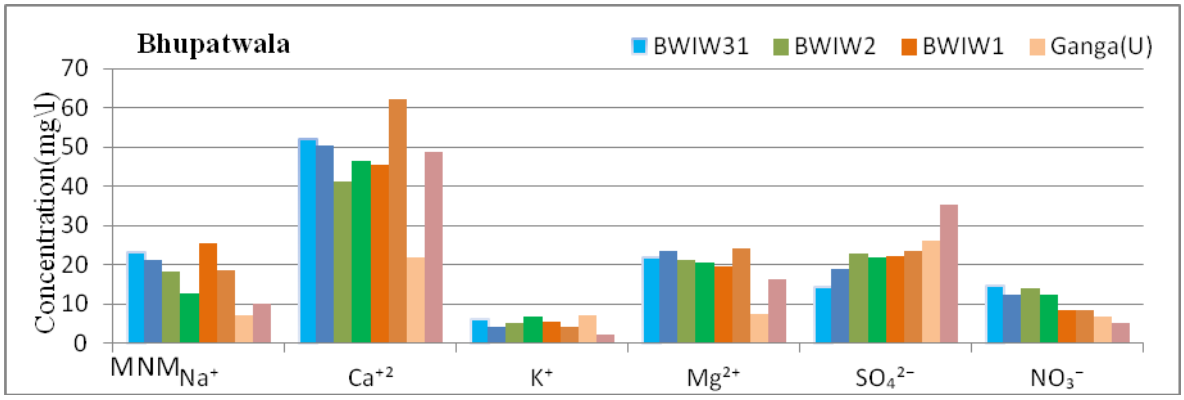


Figure 2. Concentration Plot of major ions present in Infiltration wells and River Ganga

Iron and Manganese are essential dietary element present in water and according to WHO(2011) the recommended health based limit values for Fe^{2+} and Mn^{2+} are 2 mg/L and 0.4 mg/L, respectively. Concentration plot for Ferrous and Manganese present in River and nearby RBF wells for Bhupatwala, Pantdweep and Bairagi camp depicts, surface water has higher concentration of Ferrous and Manganese ranging from 2.1 to 5.5 mg/L and from 1.9 to 6.7 mg/L, respectively, during monsoon as high discharge and flow velocities cause erosion of Fe^{2+} and Mn^{2+} which is accumulated in riverbed during low flow in river.

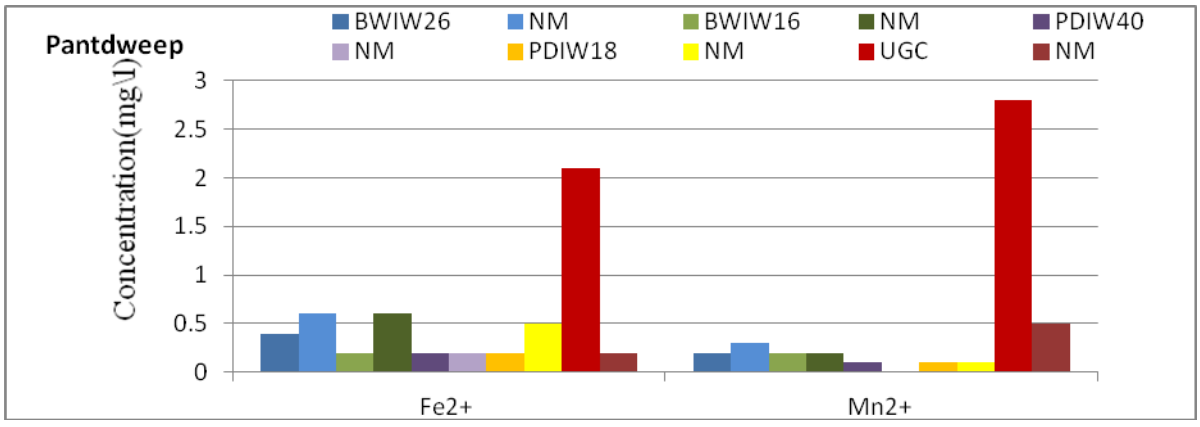


Figure 3. Concentration Plot of Ferrous and manganese present in Infiltration wells and river Ganga

Turbidity is the measure of relative clarity of water. Material that causes water to be turbid includes clay, silt, finely divided inorganic and organic matter, algae, soluble colored organic compounds, and micro organisms. The most important health-related function of turbidity is its use as an indicator of the effectiveness of drinking water treatment processes, particularly filtration, in the removal of potential microbial pathogens. Turbidity result is

visualized in figure shows that the turbidity of Ganga River (upstream and downstream of Bhimgoda barrage) is 2 to 15 times more turbid in monsoon season due to high flow velocities, high runoff and erosion of soil and riverbed materials respectively. The turbidity of the abstracted water is below the limit of 5 NTU (IS 10500, 1993) during monsoon and non-monsoon.

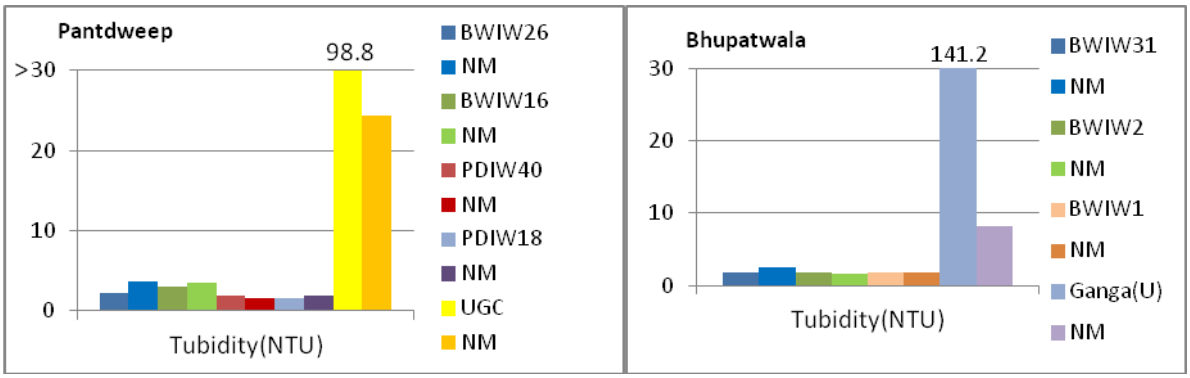


Figure 4.Turbidity (NTU) in river Ganga and Infiltration wells.

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 is complete and various hydrogeological and hydraulic data for setting up the flow model completed. Modelling of bank filtrate travel-time and flow-path in steady state condition for existing bank filtration sites in Haridwar is completed. Water quality analysis for major parameters such as turbidity and pathogens is completed for monsoon and non monsoon period.

An illustrated hypothetical example for flow model based on real site with three pumping wells has been generated to show flow paths and travel-time of imaginary particles extracted by the wells. Figure 5 and Figure 6 show the discretized setup of MODFLOW domain and flow path generated using the following datasets.

Table 1. Input data used in illustrated hypothetical example of MODFLOW model.

Model Input Data:					
a)	Model Domain	400m(along x-direction)*1000m(along y-direction) Grid size-10*10m	h)	Hydraulic Conductivity K	1m/hr
b)	3Homogeneous vertical layers	Upper layer-5m thick Middle layer-3m thick Bottom layer-50m thick	i)	H	55m
c)	Initial head	50m above the impervious stratum	j)	Depth-D	2m
d)	River width Canal width	20m, 10m	k)	Riverbed Conductivity λ	0.37m/hr

e)	Canal constant depth	2m	l)	Thickness of riverbed material	2m
f)	Pumping wells Discharge(Q)	100m^3/hr, 150m^3/hr, 50m^3/hr	m)	Time step size	Δt=1hr
g)	Transmissivity T	50m^2/hr	n)	Time period of simulation	T=720hrs

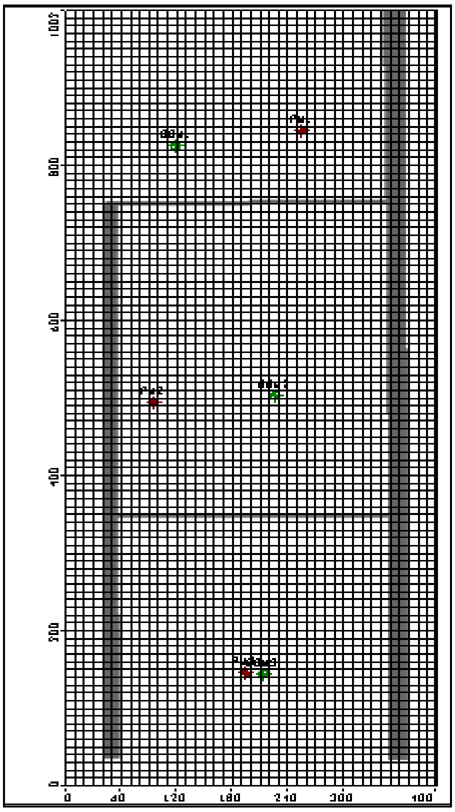


Figure5.Discretized setup of MODFLOW domain: Red circles-Pumping well; Green circles-Observation points. Total of 40*100grids, each of size 10m*10m

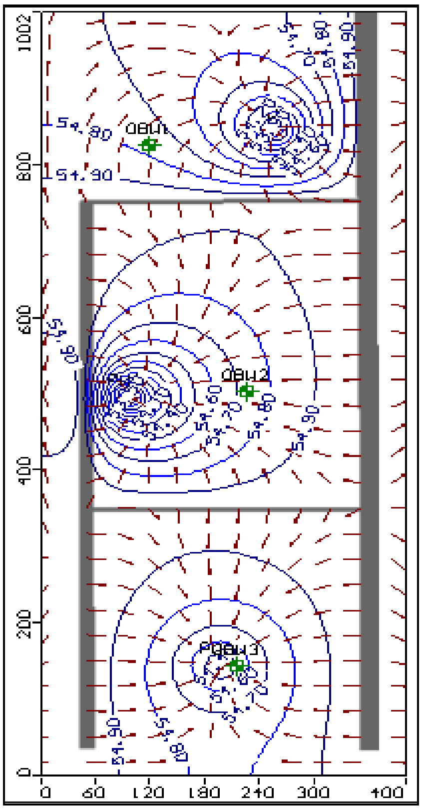


Figure6.Flowpath generated for pumping wells, river Ganga and canal.

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

HYDROLOGICAL INVESTIGATION DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2014-2015

(This includes studies which are continuing as well as new studies which are being proposed in the 41st meeting)

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**3 years** (07/12-06/15) **Continuing Study**
2	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) **Continuing Study**
3	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 B. C. Joshi (CGWB, Lucknow) Tejdeep Singh (CGWB, Chandigarh)	**2 years** (07/13-06/15) **Continuing Study**
4	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in 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) **Continuing Study**
5	Sub-marine Groundwater Discharge and Sea-water Intrusion in Coastal Aquifers of East Coast, India	M. S. Rao (PI)	**2 years** (06/14-05/16)
6	Monitoring Isotopes in Air Moisture in Parts of Himalayas (Himachal Pradesh & Uttarakhand) for investigating the Cloud Condensation	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**2 years** (06/14-05/16)
SPONSORED PROJECTS			

S. No.	Study	Team	Duration/ Status
7	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**
8	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**
9	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**
10	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 8 months** (02/13-09/14) **Continuing Study**
11	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Sudhir Kumar (PI) S. P. Rai S. D. Khobragade C. K. Jain P. K. Garg	**2 years** (05/13-04/15) **Continuing Study**
CONSULTANCY PROJECTS			
12.	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management	Suhas Khobragade (PI)	**Initially 2 years** (7/11-12/13**)** **(being extended upto 3/15)**
13.	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur	Sudhir Kumar (PI)	**3 years** (05/13-04/16) **Continuing Study**
14.	Impact Assessment of Ash Pond on the Groundwater Quality in the Surrounding Villages of NTPC Simhdri through Stable Isotopic Studies	Sudhir Kumar (PI)	**1 year** (07/13-06/14) **Completed**

S. No.	Study	Team	Duration/ Status
15.	Isotopic Characterization of Groundwater of District Raigarh, Chhattisgarh	S. P. Rai (PI)	**6 months** (04/14-09/14) Proposed to be extended
16.	Hydrogeological Studies for Ash Pond of 2 X 525 MW Maithon Power Limited and an Abandoned Coal Mine, District Dhanbad, Jharkhand	Sudhir Kumar (PI)	**3 months** (06/14-08/14) **Extended till 12/14**
17.	Possible impact of construction activities in Kansal area (Mohali, Punjab) on water flow to Sukhna lake in Chandigarh	Suhas Khobragade (PI)	2 months (9/14-11/14) **(Draft Report submitted)**

NEW STUDIES PROPOSED BY HYDROLOGICAL INVESTIGATIONS DIVISSION FOR 2014-15

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1	Interaction between groundwater and seawater along the north east coast of India	M. S. Rao (PI), Sudhir Kumar and Pankaj Garg	**2 years** (01/15 - 12/16)
2	Isotopic investigation of benchmark Himalayan glaciers.	M. S. Rao (PI), S.P. Rai, Sudhir Kumar and Pankaj Garg	**2 years** 01/15 – 12/16
	Assessment of dissolved radon concentration for groundwater investigations in Haridwar district	Pankaj Garg (PI), Sudhir Kumar, M. Someshwar Rao	**1 year** 01/15 – 12/15

INTERNAL STUDIES:

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

Title of the Study : **Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab**

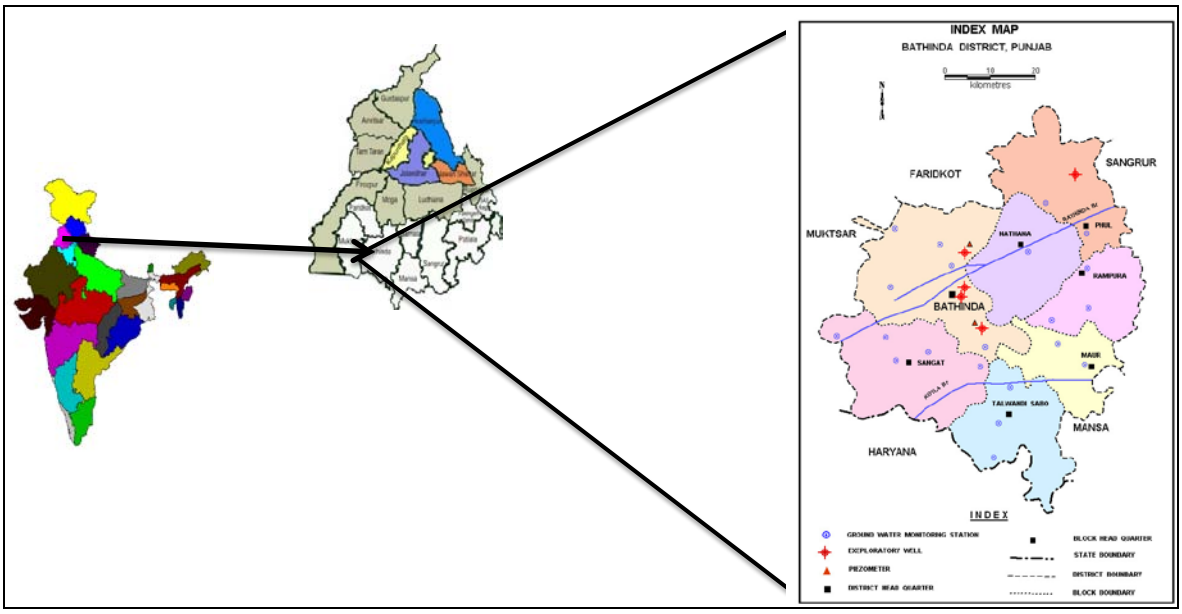
Study Team : M. S. Rao (PI), C. P. Kumar and Gopal Krishan

Type of Study : Internal

Date of Start : July 2012

Date of Completion : Final Report will be submitted by Feb 2015

Location Map



Study Objectives

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

Statement of the Problem

The state Punjab is known for problem of groundwater availability in Bist Doab and groundwater quality problem in the south west parts of Punjab. The present study is taken up to investigate the quality of groundwater and the cause for it in the Bhatinda district that falls in the southwest parts of Punjab.

Study area

The study is carried out in the Bhatinda district of Punjab. The district covers an area of 3369 sq. km and comprises of 7 blocks (Bhatinda, Nathana, Rampura, Phool, Talwandisabo, Sangat, Maur). The study area is situated between 29°33' and 30°36' North latitude and

74°38' and 75°46' East longitudes in the southern part of Punjab (Figure1). The average rainfall is 410 mm. The district is situated within the Satluj-Ganga plain.

Methodology

The random groundwater samples were collected from 22 sites (Figure 1) covering the entire 7 blocks of the Bhatinda district using standard protocol. Sampled wells/tube wells were selected to represent different geological formations as well as land use pattern and different aquifer. EC and geographic position of sampling location was recorded in the field. The samples were analysed for major cations and anions using Dionex Ion Chromatograph ICS-5000 and stable isotope ($\delta^{18}O$) on DI-IRMS in NIH, Roorkee. Total permanent water hardness was calculated as sum of calcium and magnesium hardness.

Results & Discussion

Electrical conductivity (EC): EC ranged from 310 to 6000 µS/cm at 25°C. Around 83% of the district area has been found to have EC value more than 1000 µS/cm at 25°C, 60% of the area has EC value more than prescribed limit of 1500 µScm-1 for drinking water (WHO, 2008) and 25% of the district area is having EC value more than 3000 µS/cm at 25°C. The high values of EC are found in the areas adjacent to the Bathinda branch of Sirhind Canal.

Cations: In the dissolved ion concentration, sodium (Na^+) values ranged from 4.70 mgL^{-1} to 509 mgL^{-1} and the potassium (K^+) values range from 8.20mgL^{-1} to 199 mgL^{-1}. The highest Na^+ (509 mgL^{-1}) were found in Ramgarh which exceeds the permissible limit (200 mgL^{-1}) of WHO. The total hardness varies from 151mgL^{-1} to 1468 mgL^{-1}. The value of Ca^{++} varied from 18 to 229 ppm with an average of 78.1 ppm. The highest to tune of 229 ppm is found in groundwater sample collected from Mehta.

Anions: The fluoride (F) values ranges from 0.60 mgL^{-1} to 4.40 mgL^{-1}. In the district; north, central and small patches in south-western and eastern parts have high values of fluorides exceeding the permissible limits of 1.50mgL^{-1} for drinking water standards. The chloride (Cl^-) values range from 7.30 mgL^{-1} to 502 mgL^{-1} and the nitrate (NO^{3-}) values range from 2.70 mgL^{-1} to 217 mgL^{-1}. The sulphate (SO_4^{--}) values ranged from 27.10 mgL^{-1} to 784 mgL^{-1} indicating that in some areas (such as in Mehta, Phul, Bhatinda, Rama, Ablu, Ramgarh and Balluana) the concentration of nitrate exceeds the permissible limit (50 mgL^{-1}). The sulphate concentration was the highest in Balluana (217 ppm). The water quality data was also analyzed for sodium percentage and SAR. The sodium percentage calculated for the samples indicated that 23% of the analyzed samples fall outside the permissible limits

Inter-relation between Water quality and Isotopic signatures: EC and stable isotope $\delta^{18}O$ in groundwater show a gross similar spatial distribution indicating a gross overall relation between these two parameters. An increase in EC of groundwater from its low value 500 µS/cm to an intermediate value 800 µS/cm relates with isotopic ($\delta^{18}O$) enrichment from -11.5‰ to -9.6‰. Beyond -9.6‰, $\delta^{18}O$ does not enrich much (remains around -8‰) but, the EC of groundwater is observed to vary over a range up to 3000 µS/cm. This indicates the additional source of salts for increase of salinity beyond 800 µS/cm as due to anthropohgenic or geogenic reasons. The distribution of nitrate, fluoride, sodium is not found linked with stable isotope composition of water. Thus, higher EC of groundwater (>800 µS/cm) is due to addition of these salts of anthropogenic or geogenic origin.

Conclusion: The salinity in groundwater in Bhatinda district is due to enrichment of salt content due to evaporation of water from shallow water table, anthropogenic & geogenic reasons (as seen from nitrate, sodium and fluoride concentration in groundwater). The salinity increase due to evaporation of water from shallow water table can be controlled by

limiting the excess use of canal water for irrigation while anthropogenic contamination can be managed by controlling excess use of fertilizers effect. Further investigation is needed to trace the source and fate of geogenic source of contamination.

Project Status

The study was taken up in technical collaboration with Department of Geology, Punjab University (PU), Chandigarh. NIH took up the responsibility to investigate the isotopic and hydrochemical details whereas PU took up the responsibility to conduct hydrogeological surveys and geochemical investigations though external source of funding. NIH with its internal funding completed the 1st phase of isotopic and hydrochemical investigations. However, PU received some limited funds in the 2nd year of the project and this was utilized in conducting an International Conference (AWRDM- 2013) in October, 2013 at PU, Chandigarh. As no further, funds were received at PU to continue the project, the project could not be continued further. Therefore, the project will be closed with submission of project report on the basis of the research findings of NIH.

Outcome of the Project:
The results of the project work have been reported in 3 publications (1 international conference and in 2 research papers). One International Conference Advances in Water Resources Development and Management (AWRDM -2013) was conducted during October 23-27, 2013 at Punjab University, Chandigarh.

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

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

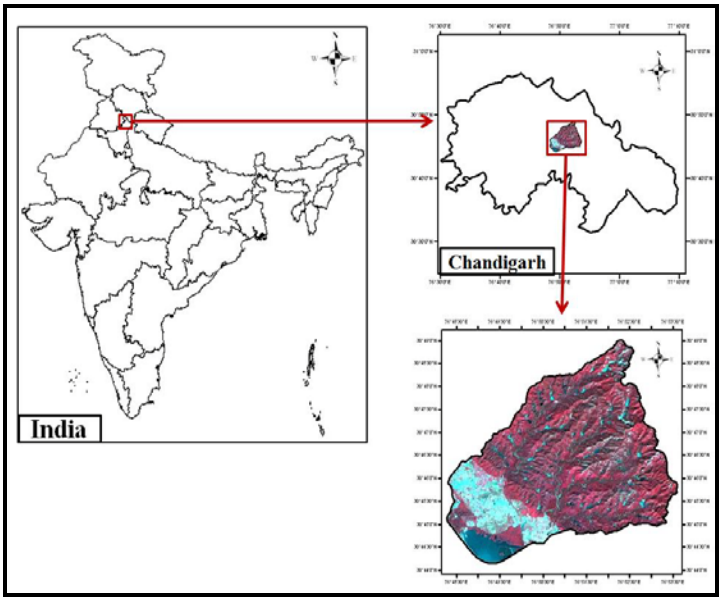
Study Team : S. D. Khobragade (PI), C. P. Kumar, Sudhir Kumar, A. R. Senthil Kumar, P. K. Garg, V. K. Agarwal

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, and
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 Achèvements

Objectives	Achievements
To study inflow regime of the lake	Inflow has been estimated using water balance approach for 2011, 2012 and 2013 Work under progress for 2014
To study seepage losses from the lake	-Seepage has been indirectly estimated using water balance approach and based on analysis of long term of lake water levels - analysis of isotopic data of piezometers is planned. Data collection and sample analysis is under progress
To analyze long term trends in rainfall and evaporation	Analysis carried out based on trend line. Analysis based on statistical tests shall be carried out in next quarter.
To study the impact of aquatic weeds on lake evaporation	In view of the fact that after the complete drying of the lake in 2012 summer and

	subsequent dredging, the weeds have vanished from the lake for the time being. So this objective has been dropped.
To study water availability in the lake	Water balance has been completed for the years 2011-12, 2012-13 and monsoon season of 2013. Analysis for monsoon season of 2014 is under progress.

Analysis and Results

Following observations have been made based on the water balance of the lake:

(i) Depending upon the rainfall characteristics, the lake can get a total inflow of about 200 Ham to 700 Ham in a water year (July to June), including direct rainfall over it and through surface runoff from the catchment. The contribution of direct rainfall may vary from 120 Ham to 200 Ham while the contribution by surface runoff from catchment may vary from 80 Ham to 500 Ham. During deficit rainfall years, the contribution from direct rainfall over the lake may be more than the runoff from the catchment.

(ii) Depending upon the rainfall characteristics, during monsoon season (July to September), the lake can receive about 200 Ham to 560 Ham of total inflow. The contribution of direct rainfall may vary from 100-150 Ham while the contribution of runoff from catchment may vary from 100-410 Ham.

(iii) Depending upon the water received by the lake during monsoon, the total losses from the lake in a water year (July to -June) may vary from 300 Ham - 450 Ham.

(iv) Depending upon the water levels of the lake, the seepage losses from the lake in a water year (July-June) can vary from 0 (zero) to 175 Ham. The seepage losses may vary from 0-60 Ham during monsoon (July-September) and 0-150 Ham during the post monsoon months (October-June). Higher is the post monsoon water level reached by the lake, more would be the seepage losses. At levels of 1956.3 m and below, the losses would be almost zero or negligibly small.

(v) Depending upon the water available in the lake, evaporation losses in a water year can be upto 300 Ham. The water losses due to evaporation during monsoon can be upto 80 Ham. As far as post monsoon season of October to June is concerned, the evaporation losses may vary from about 150 Ham- 220 Ham.

(vi) Inflow to lake in post monsoon season is almost 100% by rainfall falling directly over the lake.

(vii) In deficit rainfall years when the water levels are significantly low, evaporation is the single most important factor determining water losses from the lake with contribution above 90%, (if the water level is below 1156.3 ft level). Evaporation is always the important cause of water loss in summer irrespective of the water availability in lakes.

(viii) Seepage losses are very significant during monsoon months and during the months immediately succeeding the monsoon months till the water levels come down to the below critical mark. If the water levels are above the critical mark, then in the winter months, when evaporation rates are generally very low, seepage is a dominant factor in deciding the decline in water level.

Future Plan

- To complete water balance for 2014 (monsoon)
- Analysis of isotope data and radon data of piezometers for better understanding of seepage from the lake

3. 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**

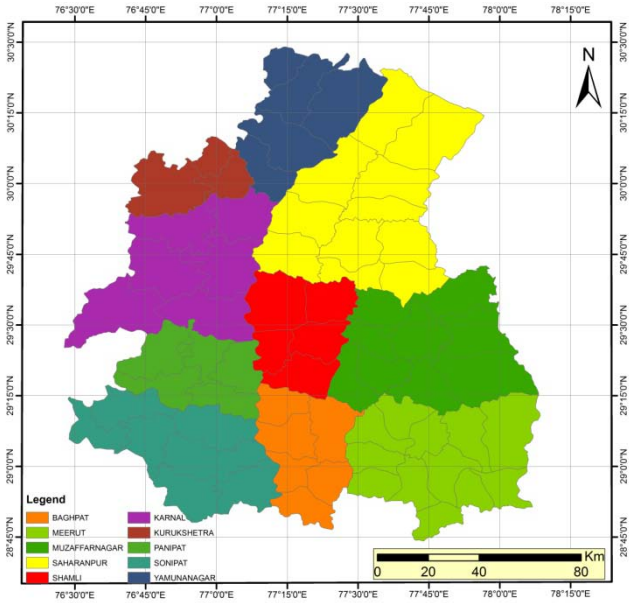
Study Team : Sudhir Kumar (PI), C. K. Jain, S. P. Rai, S. D. Khobragade, P. K. Garg, Two Officers from CGWB

Type of Study : Internal (In collaboration with CGWB under and MoU)

Date of Start : July 2013

Date of Completion : June 2015

Location Map:



Study Objectives: Objectives of the study are

i. To identify the 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 the sides of the river Yamuna,
iv. To determine the groundwater dynamics in different identified aquifers, and
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 programme 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 the seepage from canal network and irrigation return flow apart from the rainfall, which is the major source of recharge. The canal water originates 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	July, 2013 – June-2014				July, 2014 – June-2015			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
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 :

S. No.	Objective	Achievement
1	To identify the various aquifers present in alluvial tract of the Upper Yamuna Plains.	The aquifers have been identified
2	To identify the source of recharge of different aquifers, and the interaction between various aquifers.	Partially achieved
3	To investigate the continuity of aquifers on both the sides of the river Yamuna,	Not yet established
4	To determine the groundwater dynamics in different identified aquifers, and	Partially achieved
5	To estimate the groundwater velocity and replenishment potential of the deeper aquifers.	Not yet established

Present Status

1. Most of the data available with CGWB has been collected.
2. Groundwater sampling from 21 wells ranging in depth from 100-420 m have been collected from UP side.
3. Carbon-14 and carbon-13 analysis of 14 samples has been completed
4. Noble gas analysis for 12 samples has been completed
5. Forty five sampling locations from Haryana side have been finalised which includes 13 locations for IIIrd aguifer, 15 locations from IInd aquifer and 17 locations for Ist aquifer
6. Construction of aquifer geometry based on available data / information is under progress.
7. Analysis of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis is under progress.

The results achieved shall be presented during the working group meeting.

Future Plan

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

4. 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 Part of Punjab Located in Satluj River Basin using Isotopes**

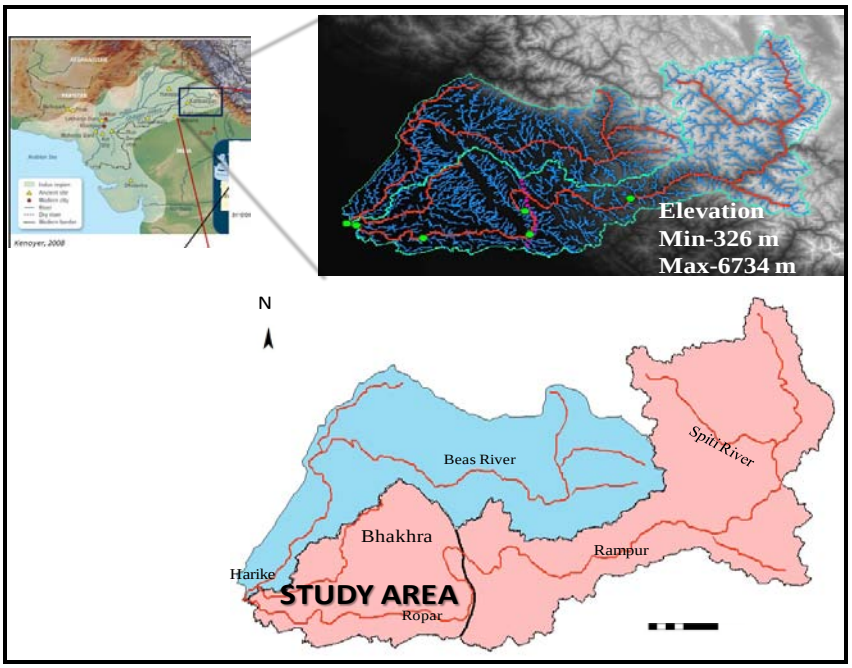
Study Team : S. K. Verma (PI), S. P. Rai, M. S. Rao, C. P. Kumar, Mohar Singh

Type of Study : Internal

Date of Start : October 2013

Date of Completion : September 2015

Study Area :



The part of Punjab located in Satluj river basin has been selected for the present study. The Satluj river is the main tributary of Indus river which originates from Mansarovar lake of Higher Himalayas at an altitude of approximately 4500 m. The Punjab is the northwestern state of India which is presently hotspot of groundwater depletion due to intensive irrigation. In Punjab, groundwater declining rate is highest in any other comparable-sized region on Earth (Rodell, M. et al., 2009).

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.

Brief 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, analysis of radon concentration		♦	♦	♦	♦			
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							♦	♦

Objectives vis-à-vis Achievements

Sr. No.	Objective	Achievement
1.	To measure radon concentration in water	Partially achieved.
2.	To identify paleo-groundwater in the study area	A total of 39 groundwater samples from intermediate/deep aquifer using tube wells for drinking water supply have been collected for tritium analysis which is under progress.

Analysis and Results

- The analysis of radon concentration in groundwater has been carried out for a total of 20 groundwater samples collected from intermediate/deep aquifers using tube wells for drinking water supply from different locations in the study area.
- It is found that the radon concentration in water varies from 1 Bq/litre to 14 Bq/litre in district Nawanshahar district, from 5.5 Bq/litre to 24 Bq/litre in district Hoshiarpur and from 0 Bq/l to 4 Bq/l in district Ropar. These values fall under the safe limit recommended by the World Health Organization (WHO) for drinking water i.e. 100 Bq/litre.
- The electrical conductivity of groundwater samples has been measured at 20 locations at the time of sampling which varies from 250 µS/cm to 470 µS/cm in the study area.
- In addition to above, a total of 20 ground water samples were collected from intermediate/deep aquifers using tube wells for drinking water supply each from 20 locations. These samples are being analysed for tritium dating using Tritium Enrichment unit and Quantulus available in Nuclear Hydrology laborator**y**.

Future Plan : As per activity chart

5. PROJECT REFERENCE CODE:

Title of the study : Sub-marine Groundwater Discharge and Sea –water Intrusion in Coastal Aquifers of East Coast, India

The study has not been taken up as in the 40th working group meeting it was suggested to revise the project proposal. The study proposal has been revised and submitted as new study.

6. PROJECT REFERENCE CODE:

Title of the Study : **Monitoring Isotopes in Air Moisture in Parts of Himalayas (Himachal Pradesh & Uttarakhand) for investigating the Cloud Condensation**

The study could not be initiated as the instruments for collection of air moisture could not be installed.

SPONSORED PROJECTS

7. 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), S. K. Verma, S. Khobragade, Surjeet Singh, Sudhir Kumar, V. K. Agarwal, Rajeev Gupta, S. L. Srivastava, Vishal Gupta, Mohar Singh

Type of Study : Sponsored

Funding Agency : MoES, Government of India

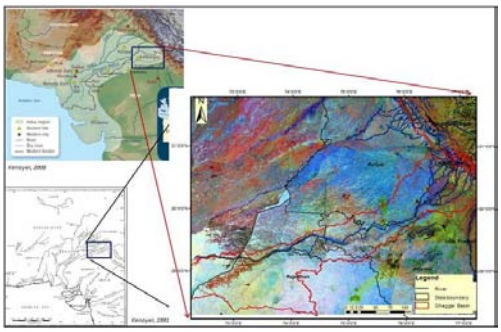
Budget : Rs. 210 Lakh (NIH component Rs. 35 lacs)

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

- Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water
- Groundwater dating using Tritium and Carbon-14
- Delineation of flow direction and recharge zones
- 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									♦	♦	♦	
First Draft Report										♦		
Second Draft Report											♦	
Final Report												♦

Objectives vis-à-vis Achievements

Objectives	Achievements
Isotopic characterization ($\delta^{18}O$ and δ^2H) of groundwater, stream and rain water Groundwater dating using the tritium and Carbon-14 Delineation of flow direction and recharge zones Identification of recharge source and zones of groundwater in the study area.	Pre-monsoon & post-monsoon samples of groundwater, river and canal have been collected and laboratory analysis completed. To date the groundwater, collected water samples enrichment of about 40 samples completed and further analysis of 40 samples is in progress. For carbon dating a proposal is submitted at NERC, UK

	Interpretation is under progress in order to identify the recharge source and zone

Analysis and Results

Isotopic Composition of Rainfall, River and Canal Water

The stable isotope data of precipitation of 12 locations of Punjab during the year 2009-2013 are used to characterize the isotopic composition of precipitation. The $\delta^{18}O$ varies from -19.4‰ (minimum) to 9.8‰ (maximum) and $\delta^{2}H$ from -150.1‰ (minimum) to 59.1‰ (maximum). The local meteoric water line is

$\delta^{2}H = 7.9 * \delta^{18}O + 5.4$, $r^2 = 0.98$, n = 148

Ghaggar river samples have been collected from its origin near to Nahan in Himachal Pradesh to downstream upto Siras in Haryana. The $\delta^{18}O$ of river varies from -7.3‰ to -5.3‰ and $\delta^{2}H$ vary between -50.6‰ to -43.8‰. The $\delta^{18}O$ in origin area (between Nahan to Panchkula) varies between -7.3‰ and -6.7‰ and between -50.6‰ and -46.4‰ for $\delta^{2}H$. Near Patiala and Sirsa isotopic composition of river is found -6.1‰ and -5.3‰ for $\delta^{18}O$ and -49.8‰ to -43.8‰ for $\delta^{2}H$ respectively. The canal water samples were collected from various sites in the catchment. The isotopic variation of canal water are found between -12.1‰ and -11.5‰ for $\delta^{18}O$ and -80.9‰ and -74.9‰ for $\delta^{2}H$. The isotopic composition of canal water is depleted in comparison to Ghaggar river and local precipitation. The source of canal water is Bhakara dam, which is on Satluj river.

The spatial variation of $\delta^{18}O$ values of groundwater of shallow depth show that $\delta^{18}O$ varying between -4‰ and -12‰. The enriched $\delta^{18}O$ values are found in the upper part of the catchment while depleted values in the middle and lower part of the catchment. The depleted isotopic signature of groundwater in the middle and lower part 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.

The electrical conductivity (EC) of Ghaghar river and canal water is found in the range of 400 µS/cm to 450 µS/cm and 200 µS/cm to 220 µS/cm, respectively. The canal and river water samples show low salt values than the desirable value of Indian & WHO Standards (782 µS/cm). EC ranges between 230 µS/cm and 10500 µS/cm in shallow aquifer, 260 µS/cm to 3900 µS/cm in middle aquifer and 420 µS/cm to 9500 µS/cm in deep aquifer, respectively. In shallow aquifer, EC ranges 250 µS/cm to 2000 µS/cm in upper reaches of study area, 500 µS/cm to 1000 µS/cm in middle part of study area and 1000 µS/cm to 10500 µS/cm in lower part of study area. The southern part of the basin is more saline.

There is marked variation in isotopic and chemical composition of groundwater which indicates complex system of recharge.

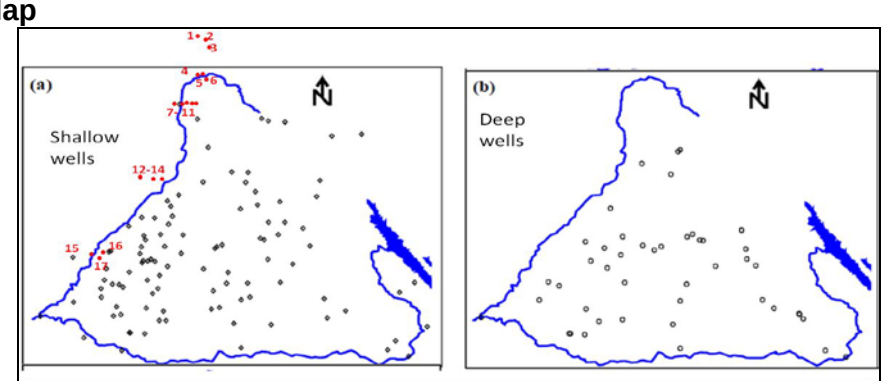
Future Plan

- Post-monsoon sampling of groundwater for stable and radio isotope measurements
- Analysis of water level data and estimation of volume of water withdrawn
- Preparation canal map of the study area
- Estimation of canal recharge to groundwater

8. PROJECT REFERENCE CODE: NIH/HID/IAEA-1/2012-15

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 and S. P. Rai
Type of Study	:	Sponsored
Funding Agency	:	IAEA, Vienna
Budget	:	Euros 15,000
Date of Start	:	September 2012
Date of Completion	:	August 2015

Location Map



Locations	Dhaki	Tangu	Dam -tal	Kath- garh	Mir- thal	Beas near Mirthal	Jagatpur Kalan	Naushera pattan	Kalaut Harsha/ Leachpur
Loc. No.	1	2	3	4	5	6	7	8	9

Locations	Bahadur pur	Mushaib pur	Ghuman	Mache rai	Hargovind- pur	Fattu- dinga	Amritpur	Mundi Mode
Loc. No.	10	11	12	13	14	15	16	17

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 Beas river and Satluj river 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, 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 is an extended part of Bist doab region where groundwater is getting over-exploited.

Action Plan

Year	July 2014 to March 2015	Remarks
June 2014 to March 2015	Water sampling, analysis and data interpretation Report writing	Report preparation as per table below.

Activity Schedule (Quarterwise: July 2014 to March 2015)

Activity	1st	2nd	3rd
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		♦	♦

Objectives vis-à-vis Achievements

Objective	Status	Work Done
Assessment of depleting groundwater conditions in north-eastern parts of Punjab.	Under Progress	The water level data of the study area is continuously being monitored.
Identifying the regions where groundwater use has caused changes in chemical, stable isotopic composition and age of groundwater		Out of 1000 samples collected from new wells (marked in red colour in the figure) and those from inside the Bist doab; about 500 have been analyzed for stable isotope and 15 for tritium dating. The analysis of the remaining samples are in progress.
Identifying the areas where deep aquifers are getting modern recharge through their shallow aquifers		
Groundwater recharge/return-flow to the Beas river and Satluj river due to river water and groundwater interaction		
Assessment of artificial recharge measures		

Analysis and Results

About 500 samples collected from the 3 cross sections across the Beas river (Northern cross section: Tangru, Damtal, Kathgarh, Mirthal, Jagatpur Kalan, Dhaki, (Cross section in the middle reach: Hargovindpur, Machrai, Ghuman, (iii) Cross section in the southern side; Govindwal, Fatehabad) have been measured for stable isotope composition. The interpretation of the data and the results shall be presented during the Working Group meeting.

Future Plan

- The water levels will be monitored regularly.
- The sampling will be continued for the analysis of chemical and isotopes to achieve the above objectives

9. 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

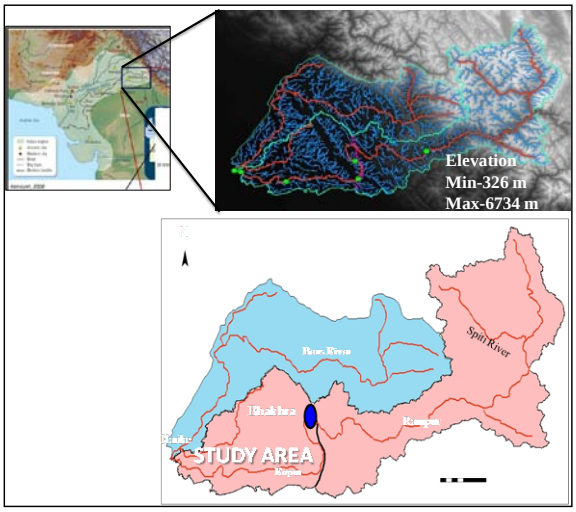
Budget : 5000 Euro per year

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
- 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 & river				♦	♦	♦	♦	♦	♦	♦		
Measurement of radon in groundwater								♦	♦	♦		
Preparation of geological & hydro geological maps of the study area				♦	♦	♦	♦	♦				
Preparation of water table and flow direction map on the basis of previous years' data				♦	♦	♦						
Interpretation of isotopic data					♦	♦	♦	♦	♦	♦	♦	
Application of conceptual model					♦	♦	♦	♦	♦	♦	♦	
Report Finalisation											♦	♦

Objectives vis-à-vis Achievements

Objectives	**Achievements**
• 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 • To assess the potential and limitations of	o Isotopic characterization ($d^{18}O$ and d^2H) of groundwater, stream and rain water o Groundwater dating using tritium o Delineation of flow direction and recharge zones o Isotopic technique has been used to separate out different component of hydrograph

the tracer techniques for routine application in hydrological studies	o Modelling approach has been attempted to separate out the baseflow component of stream discharge o Comparison of both study is under progress

Analysis and Results

Isotopic Composition of Precipitation

The isotopic composition of precipitation in study are varies from -19.4‰ to 9.8‰ for $\delta^{18}O$ and -150.1‰ to 59.1‰ for $\delta^{2}H$. The $\delta^{18}O$- $\delta^{2}H$ bi plot of precipitation in the study area shows similarity with GMWL (Rozanski *et al.* 1993) and Indian Meteoric Water Line for the north region (IMWL- North) (Kumar *et al.* 2010). The slightly lower intercept may be due to local climate.

LMWL: $\delta^{2}H = 7.9 \times \delta^{18}O + 5.4$; $R^2 = 0.97$, n = 119 (eq. 1)

IMWL- North: $\delta^{2}H = 8.15 \times \delta^{18}O + 9.55$; $R^2 = 0.99$ (eq. 2)

GMWL: $\delta^{2}H = 8.17 \times \delta^{18}O + 11.27$; $R^2 = 0.99$ (eq. 3)

Isotopic Composition of River

The $\delta^{18}O$ of Rivers Satluj varies between -12.7‰ to -6.8‰ and $\delta^{2}H$ from -87.9‰ to -48.5‰. The isotopic composition of river gets enriched as water move fromm Ropar to Harike (downstream). The depleted isotopic composition of Satluj River at Ropar is due to major contribution from the higher Himalayas. As river move downstream, enrichment of $\delta^{18}O$ of river water is observed which may be due to the contribution from groundwater. The regression lines derived for the river water is given below:

$\delta^{2}H = 6.7 \times \delta^{18}O - 3.2$; $R^2 = 0.99$, n = 98 (eq. 4)

Isotopic Composition of Groundwater

The groundwater samples were collected from existing dug well, hand pump and tube wells. The depth of dug well, handpumps and tube wells represents to different depth of water level. The depth of open well, dugwell, hand-pumps and tubewells were collected from the sampling sites. The overall depth data indicate that handpumps are bored up to depth of 80 m and tubwells below the 80 m depth.

Open well and Handpump = <80 m
Tubewell of private farmers and Government = > 100 m

The oxygen isotope ratio ($\delta^{18}O$) of groundwater up to depth of 80 m varied from -12.4‰ (minimum) to -4.7‰ (maximum) and hydrogen isotopic ratio ($\delta^{2}H$) from -85.1‰ (minimum) to -32.4‰ (maximum). The $\delta^{18}O$ of groundwater below the depth of 100 m varied from -11.3‰ (minimum) to -5.4‰ (maximum) and $\delta^{2}H$ -81.6‰ (minimum) to -35.2‰ (maximum).

The $\delta^{18}O$ and $\delta^{2}H$ relationship for groundwater collected upto depth zone of <80 m and >100 m depth has been developed. The regression analysis between $\delta^{18}O$ and $\delta^{2}H$ of the data of different depth gives the best fit line (BFL) as:

$\delta^{2}H = 6.7 * \delta^{18}O - 1.5$ (n = 96, $r^2 = 0.98$) (< 80 m) (eq. 5)

$\delta^{2}H = 7.6 * \delta^{18}O + 4.9$ (n = 76, $r^2 = 0.92$) (>100 m) (eq. 6)

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.

In the present study, baseflow separation has been carried out using following non-tracer based methods, (i) Local Minimum Method, (ii) One Parameter Digital Filter, (iii) Eckhardt Digital, and (iv) Modified Eckhardt Digital Filter

The results of baseflow separation hydrograph obtained using filter methods are shown in Figure along with observed discharge hydrograph.

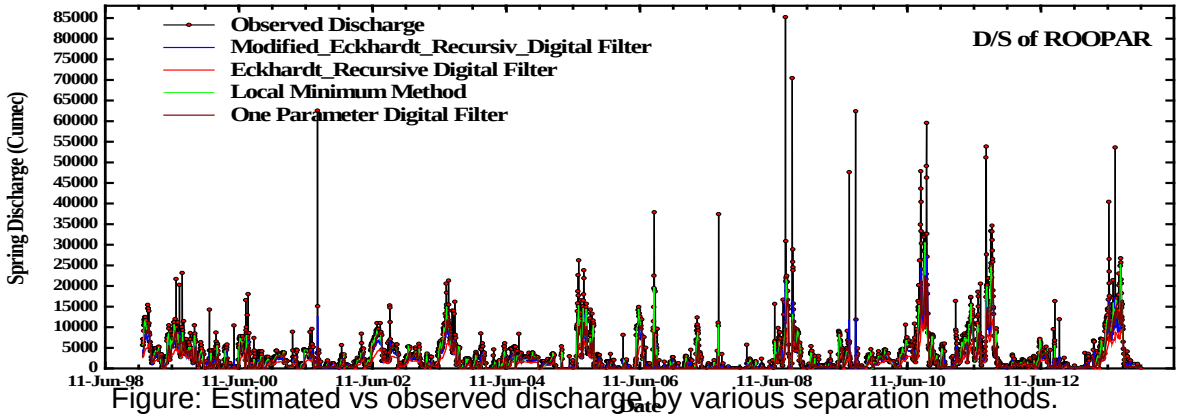


Figure: Estimated vs observed discharge by various separation methods.

The results as well as their analysis will be presented in more details during WG meeting.

Future Plan

- 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.
- Efforts will be made for the tritium-helium dating of groundwater from IAEA.

10. 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 and Gopal Krishan
Type of Study	:	Sponsored
Funding Agency	:	BGS-DFID
Budget	:	£ 28,900
Date of Start	:	February 2013
Date of Completion	:	September 2014

Status: Project completed.

In the project, a large amount of groundwater data (water level and water quality) of Ganga basin has been collated. In addition to this, isotopic and hydrochemical analysis of groundwater in the Doab region has been carried out. The following inferences have been drawn from the isotopic and hydrochemical of water samples of Bist Doab region:

Groundwater Quality: On the basis of comparison of water quality parameters measured at 26 sites it is found that groundwater quality in deeper aquifer is good at all the places. In the case of shallow aquifers, groundwater quality is good to moderate type. Among all the measured locations, poorest water quality is observed at site Jandiala (Shallow groundwater quality at Jandiala is: EC = 1540, pH =6.5, Ca =147 mg/l, Mg =46.5mg/l, Na=132 mg/l, K=7mg/l, HCO_3 =656 mg/l, Cl = 151 mg/l, SO4=37, NO3 =73 mg/l, F = 0.2mg/l). Fluoride concentration over 1 mg/l is observed only at two sites Banga and Mehli.

Groundwater dating: Groundwater dating using CFC and environmental tritium technique provided the age range of shallow aquifer in the range 15 – 45 years with a mean age of 25 years whereas, age of groundwater in the deeper aquifer ranged 38-53 years with mean age 46 years. The withdrawal of groundwater from deeper wells for irrigation and its subsequent transfer to shallow aquifer as return flow component has resulted into isotopic and chemical mixing and thereby change in quality (isotopic and chemical) of shallow groundwater. The deeper aquifers of the Bist Doab region are getting recharged mainly from Bhabhar region. The excessive groundwater withdrawal in the central Bist Doab region especially from deeper aquifers has resulted into the enhanced groundwater flow conditions from the recharge zones to the central Bist Doab region. At few locations where shallow and deep aquifer inter-connectivity (leakage) exists, the excessive withdrawal has also resulted into recharge of deeper aquifers from shallow aquifers (and accordingly change in isotopic and water quality of deeper aquifers).

The draft report has been submitted to the funding agency for comments and suggestion.

11. 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 Tea	**:**	Sudhir Kumar (PI), S. P. Rai, Suhas Khobragade, C. K. Jain, P. K. Garg
Type of Study	**:**	Sponsored
Date of Start	**:**	May 2013
Date of Completion	**:**	April 2015

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

NEW STUDIES

12. PROJECT REFERENCE CODE: NIH/HID/INT/2014-16/1

Title of the Study : **Interaction between groundwater and seawater along the north east coast of India**

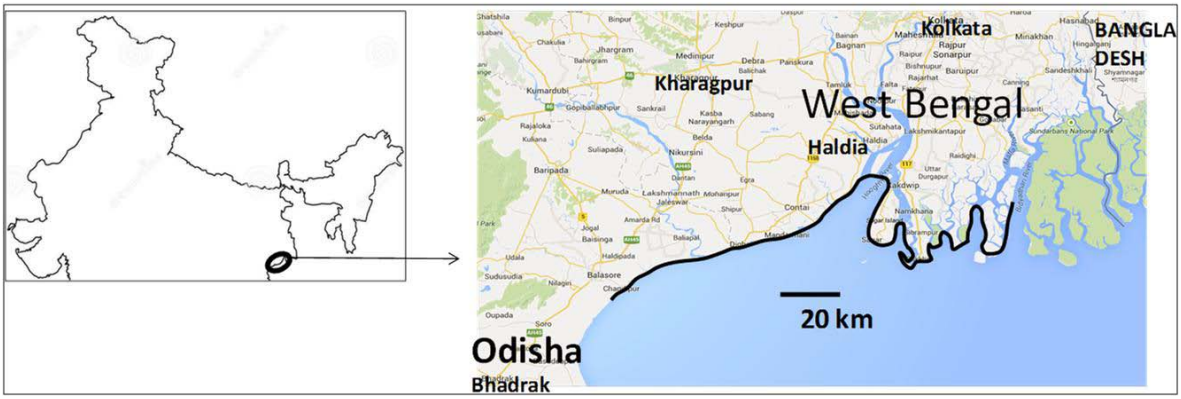
Study Team : M. S. Rao (PI), Sudhir Kumar and Pankaj Garg

Type of Study : Internal

Date of Start : January 2015

Date of Completion : December 2016

Location Map:



Study Objectives

To study the seawater-groundwater interaction region in the coastal aquifers in the north-east coast using:

(i) To identify the areas affected by sea water ingress in the study area, and
(ii) To investigate the dissolved radon concentration in groundwater in the region

Studies on groundwater-sea water interaction are important in the Indian context due to the facts that India is bordered by 7,517 km long coastline. Groundwater is a major dependable source of water for the towns and cities along the coast. Many important cities including the mega cities like Kolkata, Chennai, Mumbai are located along the sea coast and fresh groundwater resource in the coastal aquifers is reducing due to increasing groundwater withdrawal, change in land use practices and also due to climate change.

Methodology

In the present study, groundwater -seawater interaction along the east coast of India will be investigated by sampling and analyzing groundwater of north east coast for EC, temperature, pH, stable isotopes (δD & $\delta^{18}O$), dissolved radon-222 concentration and major ions. Stable isotopes will be used to investigate the cause for the high salinity in groundwater and in case of mixing of seawater to estimate the seawater-groundwater missing ratio. Dissolved radon-222 concentration will be used to map the regions where fresh groundwater discharge into the sea is taking place. The chemical data, water level data and isotopic data

will be suitably integrated for the phenomenological interpretation of the hydrological process in the study region.

Action Plan

Activity Schedule (Quarterwise: January 2015 to December 2016)

S. No.	**Activities**	**Quarters**							
		1	2	3	4	5	6	7	8
1.1	Review of literature	√	√	√					
1.2	Site selection & preparation of index map of the study area	√	√						
1.3	Collection and compilation of data	√	√						
1.4	Field work, sample collection and analysis of water samples		√	√	√	√	√		
1.5	Data interpretation					√	√	√	
1.6	**Project report & publications**							√	√

2. PROJECT REFERENCE CODE: NIH/HID/INT/2014-16/2

Title of the study: Isotopic investigation of benchmark Himalayan glaciers.

Study Team : M. S. Rao (PI), SP Rai, Sudhir Kumar and Pankaj Garg

Technical Collaborator: Prof. AL Ramanathan, JNU, New Delhi

Type of Study : Internal

Date of Start : December 2015

Date of Completion : December 2016

Background of the study:

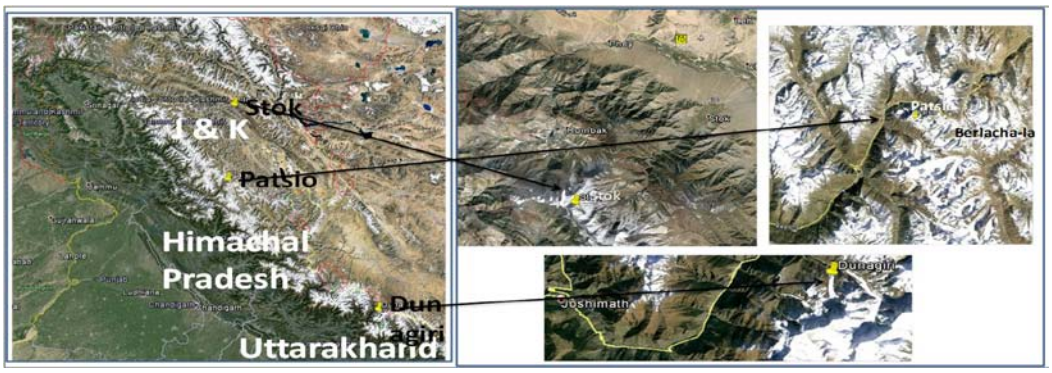
NIH has recently invited proposals to undertake an integrated study on "*Long-Term Sustainability of Himalayan Water Resources*" for funding through DST, Govt of India under the project- *"National Mission for Sustaining the Himalayan Eco-system"*. Considering this new development, it is proposed to conduct a pilot study on isotopic investigation of a few Himalayan glaciers.

The Stable isotopic composition of precipitation is influenced by the evaporation and condensation history of air mass and is closely linked to source of origin of the moisture, climatic parameters such as surface air temperature, precipitation amount, and relative humidity of the atmosphere. Thus, inter-comparison isotope records of glaciers and their melt water provide a direct means to characterise these glaciers and their environments. Stable isotope data on Himalayan region is very sparse. In the present study, a preliminary survey of snow, glacial core and glacial melt water of one glacier each from Uttarakhand, Himachal Pradesh and Ladakh Himalaya will be conducted to investigate isotope characteristic of these glaciers.

Methodology

The study will be taken up jointly with JNU, New Delhi which has agreed to provide support in sampling of snow, glacial core and glacial melt water from few glaciers between Uttarakhand to Ladakh will as per the requirement of isotopic analysis (however, no funds will be provided to JNU for the field work). Chemical analysis of the collected samples will be conducted at JNU and NIH as per the availability of facility at these institutes. An air-moisture sampling units for isotopic analysis will be installed at suitable site where a meteorological station is also available. Samples will be analyzed for stable isotope details at NIH. analysis of samples. The data will be interpreted in terms of climate-glacier interaction.

Study Area:



Study Objectives

(i) Generating the isotope data base on snow & glaciers in the Himalayan region between Uttarakhand and Ladakh
(ii) Assessment of spatial variability in isotopic & chemical characteristic of glacial environment
(iii) Use of isotope technique to understand the accumulation and ablation of (Himalayan) glaciers

Action Plan

Activity Schedule (Quarterwise: January 2015 to December 2016)

S. No.	**Activities**	**Quarters**							
		1	2	3	4	5	6	7	8
1.1	Review of literature	√	√	√	√				
1.2	Site selection & preparation of index map of the study area	√	√						
1.3	Collection and compilation of data	√	√						
1.4	Workshop & training programme	√				√			
1.5	Field work, sample collection and sample analysis		√	√	√	√	√		
1.6	Data interpretation					√	√	√	
1.7	**Project report & publications**							√	√

3. PROJECT REFERENCE CODE: NIH/HID/INT/2014-16/

Title of the Study : Assessment of dissolved radon concentration for groundwater investigations in Haridwar district

Study Team : Pankaj Garg (PI)
Sudhir Kumar
M. Someshwar Rao

Type of Study : Internal

Date of Start : January 2015

Date of Completion : December 2015

Location Map

Objectives

1. Mapping the spatial distribution and temporal fluctuation in radon levels in groundwater in Haridwar district

2. To investigate the effect seasonal groundwater levels fluctuations on fluctuation in radon levels.

Background of the study

Radon in groundwater originates due to decay of parent radioactive member radon-226 which is derived from the decay of the ultimate parent source uranium-238. The uranium-238 is present in groundwater as uranyl complex or is present in the host aquifer matrix as radioactive contaminant. Solubility of parent members of radon (radium and uranium) in groundwater depends upon geochemical conditions and temperature of groundwater. Radon-222 concentration in groundwater is a function of radioactivity concentration of radium (and hence uranium) in aquifer matrix, aquifer porosity (dry pores may lead to escape of radon) and physico-chemical condition of groundwater. During rainfall recharge, moisture filled pores in the vadose zone may slow down the escape rate of radon and also rise in groundwater levels due to rainfall induced groundwater recharge may dilute the radon levels in the groundwater. Thus, radon concentration in groundwater at a given location

depends on the local hydrogeology, groundwater fluctuation and soil moisture conditions. Thus, a temporal variation in dissolved radon concentration in groundwater may provide a new way to look into the aquifer system and recharge conditions. Due to the short half life of radium & radon isotopes compared to timescales at which groundwater levels and soil moisture fluctuation take place; the variation of these hydrological parameters may get recorded in the radon signals.

Study area & methodology

The present study will be conducted in the district Haridwar which is considered to be the major recharge zone spanned in the Bhabhar-Siwalik region and the local recharge zones along the canal length and along the western bank of the river Solani. Groundwater samples from the study region will be analyzed for radon concentration during ptre and post monsoon seasons to generate the background radon concentration in the shallow aquifer, to investigate the recharge induced variation in radon concentration and to decipher change in radon concentration along the confined aquifer due to variation in radioactivity in the aquifer matrix. Samples will also be collected and analyzed for stable isotope analyze to support and collaborate the results and the inferences of radon measurements.

Action Plan

Activity Schedule (Quarterwise: January 2015 to December 2015)

S. No.	**Activities**	**Quarter**			
		1	2	3	4
1.1	Review of literature	√	√		
1.2	Site selection	√			
1.3	Collection and compilation of data		√		
1.4	Field work, sample collection and analysis of water samples	√	√	√	
	Data interpretation		√	√	
1.5	**Project report & publications**			√	√

SURFACE WATER HYDROLOGY DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2014-15

S.No. & Ref. Code	Title	Study Team	Duration
Internal Studies			
1. NIH/SWD/NIH/12-15	Sedimentation Studies for Pong Reservoir, Himachal Pradesh	A. R. Senthil kumar Manohar Arora Suhas D Khobragade Avinash Agarwal Sanjay Jain	3 years (April 2012 to March 2015)
2. NIH/SWD/NIH/12-15	Study of Hydro-Meteorological Droughts For Chitrakoot Bundelkhand Region In India	R.P. Pandey	3 years (April 2012 to March 2015)
3. NIH/SWD/NIH/13-15	Application of DSS (P) for Integrated Water Resources Development & Management	A.K. Lohani Surjeet Singh Rahul Jaiswal D K Sonkusale Akilesh Verma	2 years (April 2013 to March 2015)
4. NIH/SWD/NIH/13-16	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3 Years (April 2013 to March 2016)
5. NIH/SWD/NIH/13-16	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills.	Avinash Agarwal Manohar Arora RK Nema	3 Years (November 2013 to October 2016)
6. NIH/SWD/NIH/14-15	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P.	J.V.Tyagi YRS Rao,	1 year (April 2014 to March 2015)
7. NIH/SWD/NIH/14-15	Systematic treatment and analytical solutions for surges and bores in rectangular channels (research study)	S.K. Singh	1 year (April 2014 to March 2015)
8. NIH/SWD/NIH/14-15	Status Report on “Impact of Anthropogenic and Climate Change on Sediment Load of Rivers”	Archana Sarkar	1 year (April 2014 to March 2015)
9. NIH/SWD/NIH/14-16	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State	Archana Sarkar N.K. Bhatnagar Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar	2 years (April 2014 to March 2016)
10. NIH/SWD/NIH/14-17	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	3years (May 2014 to March 2017)
11. NIH/SWD/NIH/14-17	Effect of climate change on evaporation at point scale	Digambar Singh A. R. Senthil kumar Manohar Arora	3years (June 2014 to March 2017)
12. NIH/SWD/NIH/14-17	Hydrological modelling, water availability analysis	J.P.Patra Rakesh Kumar Pankaj Mani	3years (April 2014 to March 2017)

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

1. **Title of the study:** **Sedimentation Studies for Pong Reservoir, Himachal Pradesh**

2. Study Group: Dr. A. R. Senthil kumar Sc E, SWHD
Dr. Manohar Arora, Sc D, SWHD
Dr. Suhas D Khobragade, Sc E, HID
Dr. Avinash Agarwal, Sc, F, SWHD
Dr. Sanjay Jain, Sc F, WRSD

3. Date of start: 1 April 2012

4. Duration of the study: 3 Years

5. Whether externally funded or not: No

6. OBJECTIVES OF THE STUDY:

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

7. 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.

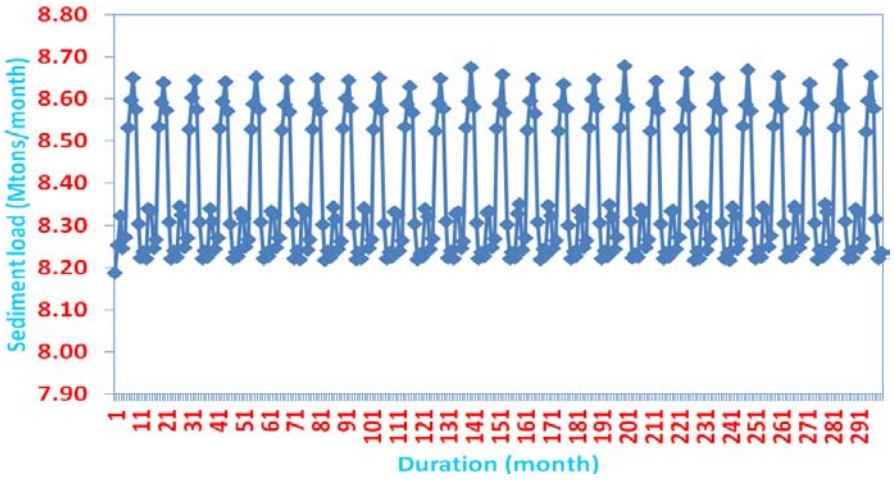
Revision of elevation-area-capacity table

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

8. 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 in the simulated series of sediment load is addressed by generating ensembles of input series and determining the sufficient number of parameter sets of the model by boots trap method.

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 probable 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 10, 50 and 90 percent probable generated series of rainfall and flow volume is found from the ensembles of the series. These values address the uncertainty in the generated data. The uncertainty in the model is addressed by developing ANN ensembles by boots trap method. 200 ANN ensembles were generated with available 276 patterns of historical data. The average probable sediment yield from the ANN ensembles were simulated from 10, 50 and 90 percent probable generated series of rainfall and flow volume. The average 10 percent probable sediment yield from the ANN ensembles for 25 years is presented in the flowing figure. The consolidated unit weight of sediment by different methods such as particle size distribution of suspended sediment concentration, hydrographic survey and porosity of uniformly distributed sediment is being computed. The expected life of the reservoir is found to be 340 years from plot of cumulative sediment yield on y-axis and time on x-axis.



Simulation of Sediment load for 10 % dependable series for 25 years

9. Expected date of completion: 31 March 2015

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

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

Name of PI : Dr. R.P. Pandey, Scientist F

Type of study : Internally Funded

Project Duration: 3-years

Date of start : April 2012

Scheduled Date of Completion: March. 2015

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:

a) Assessment of drought frequency, duration and severity in Bundelkhand.

b) Quantification of surface water and groundwater availability.

c) Assessment of total water demands for domestic, industries and agriculture.

d) Assessment of supplemental irrigation to minimize crop loss due to dryspells and droughts.

e) Delineation of zones vulnerable to different degree of drought severity.

f) To suggest an area specific plan for water management in Paisuni Basin,

Study Area : <u>Paisuni (Mandakini) Basin in Chitrakoot District</u>

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.

PROGRESS OF PROPOSED STUDY:

- Collected data/information from various sources and conducted field investigations in the study areas.
- Prepared base maps of drainage, land-use, DEM, ground water aspect map etc. using GIS.
- Analyzed rainfall data to determine frequency and severity of droughts in past decades and their impacts reported in administrative documented.
- 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.
  - Prepared map for demarcation water deficit zones in study area in the form of different clusters of villages for water supply planning.
  - 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.

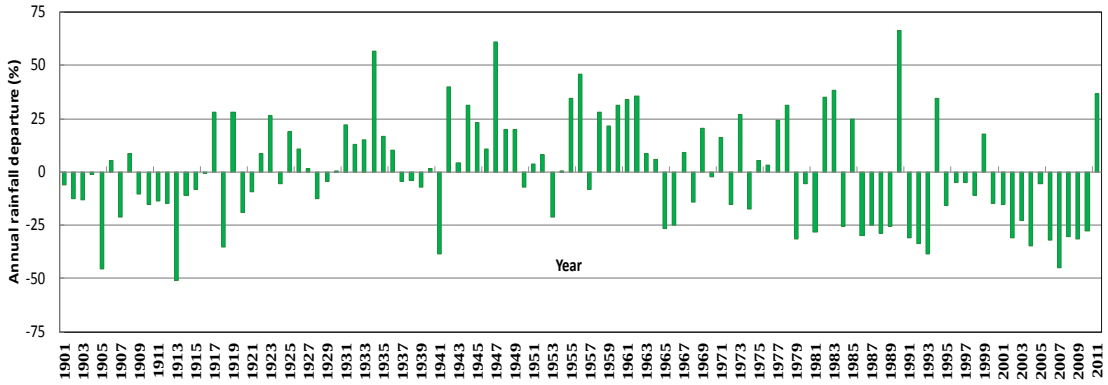


Table : Results of Critical Dry Spell Analysis in Paisuni basin covering Chitrakoot distt. UP and Part of Satna distt. MP

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)

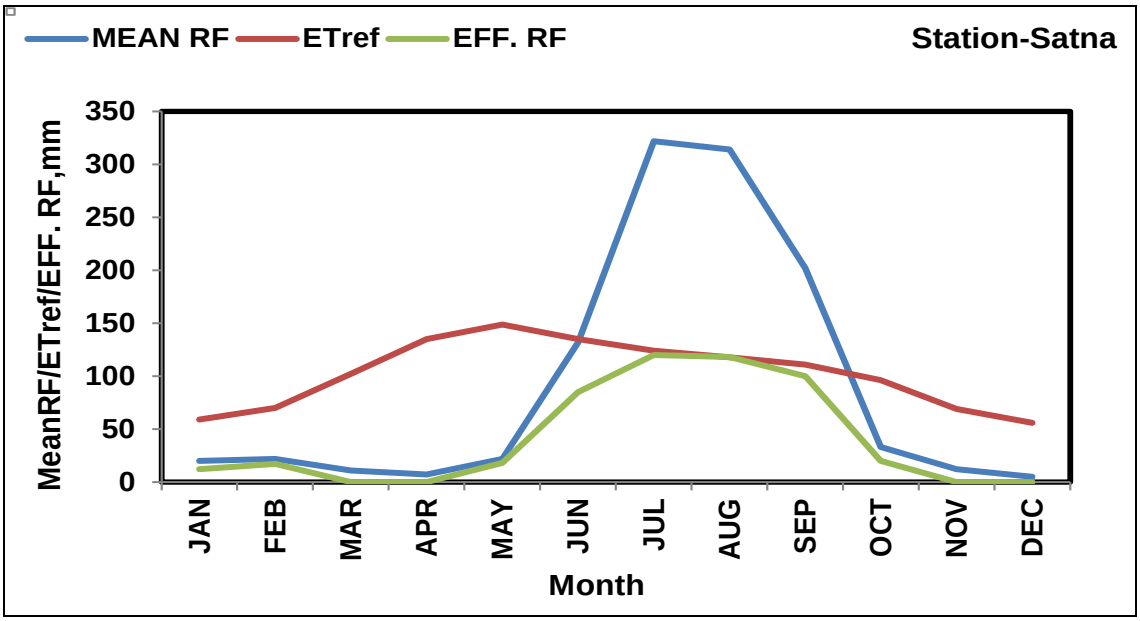


Fig: Distribution of monthly rainfall and Evapotranspiration

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

Table: Comparison of results of SDI with SPI and EDI

Year	Month	Rainfall	Monthly Av. RF	SDI-Identification	Weighted Departure	SPI 3 Month	EDI Monthly
2006	Jan	0	20	Drought-50	-2.13	-1.99	0.57
2006	Feb	20	22	Drought-2m	-0.21	-0.43	0.48
2006	Mar	34.2	11	1	2.47	0.31	0.85
2006	Apr	23.8	7	1	1.79	1.17	1.18
2006	May	25	22	1	0.32	1.19	0.62
2006	Jun	42.5	132	Drought-50	-9.54	-0.4	-0.69
2006	Jul	435.6	322	1	12.11	0.27	0.37
2006	Aug	171.5	314	1	-15.19	-0.39	-0.63
2006	Sep	44.9	202	Drought-50	-16.75	-0.64	-1.29
2006	Oct	11.5	33	Drought-50	-2.29	-1.57	-1.31
2006	Nov	0.6	12	Drought-2m	-1.22	-1.71	-1.46
2006	Dec	0	5	Drought-2m	-0.53	-0.86	-1.44
2007	Jan	0	20	Drought-50	-2.13	-1.74	-1.78
2007	Feb	71.2	22	1	5.25	0.75	-0.67
2007	Mar	25	11	1	1.49	1.04	-0.5
2007	Apr	1.8	7	1	-0.55	1.52	-0.67
2007	May	2.9	22	Drought-50	-2.04	0.08	-0.87

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

- Preparation of water storage/conservation plan to meet demand supplemental water demand to minimize crop loss during drought period and to meet drinking water supply.
- Report writing

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

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

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

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

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

1. Study Group:

Dr. A.K. Lohani, Scientist 'F' Surface Water Hydrology Division, PI
Data Collection, Data Processing, Data Analysis, Simulation, Interpretation of results etc.

Dr. Surjeet , Scientist 'D', Ground Water Hydrology Division, Co-PI
Data Collection, Data Processing, Simulation

Rahul Jaiswal, Scientist 'C' & Ganga Plains Regional Centre, Bhopal, Co-PI
Data Collection, Data Processing, Simulation
Officers from Water Resources Department, Chhattisgarh

D. K. Sonkusale, *Water Resources Department, Raipur- Data Collection*

Akilesh Verma*, Water Resources Department, Raipur- Data Collection*

2. Type of study **:** Internal

3. Date of Start : April 1, 2013

4. Date of Completion : March 31, 2015

5. Type of Study : Internal

6. Statement of 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.

7. Objectives:

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

8. The Study Area

The Seonath River Originates near village Panabaras in the Rajnandgaon District. The Basin is located between latitude 20^0 16' N to 22^0 41' N and Longitude 80^0 25' E to $82^0$35' E. The Basin area of river up to confluence with the Mahanadi River is 30,860 Sq Km . The river traverses a length of 380 Km. The main tributaries of Seonath river are Tandula, Kharun, Arpa, Hamp, Agar and Maniyari Rivers. The mean annual rainfall in the basin varies from 1005 mm to 1255 mm.

9. Analysis and Results:

The application of MIKE 11 model for rainfall runoff modeling of Arpa basin can be divided into two stages: (i) . the calibration process to determine an optimum values of the model parameters and (ii) streamflow simulation using the estimated model parameter. The computation for the mean areal rainfall carried out during this study was based on the rainfall data of three stations. In the calibration procedure, model parameters have been adjusted using automatic calibration option of the NAM model. The optimum values of the parameters obtained using auto calibration option are considered as the representative coefficient to determine the runoff from the Arpa catchment. Figure 1 illustrates the calibration results of NAM model. Figure 1 indicates that the observed and simulated values of the accumulated runoff shows a good match. Furthermore, observed and simulated runoff hydrographs of calibration are also plotted in Figure 2. The calibration had been carried out using records of daily rainfall and runoff from 2000 to 2001. The nature of rainfall pattern is spatial resulting in an uneven rainfall distribution within the catchment area. This factor directly affect the rainfall-runoff model calibration. The flow series are simulated based on the daily rainfall for the period, 2001 to 2002.

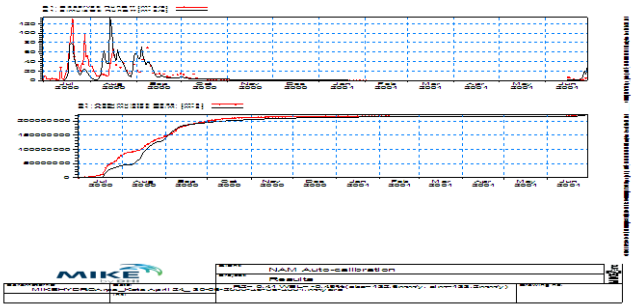


Figure 1: Observed and simulated accumulated runoff: Calibration results of NAM-MIKE-11 Model (2000-2001)

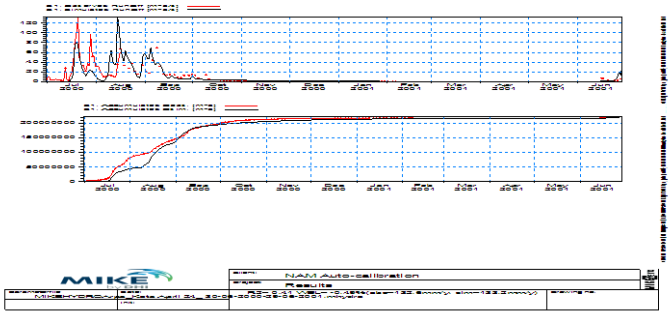


Figure 2: Observed and simulated runoff hydrographs: Calibration results of NAM-MIKE-11 Model (2000-2001)

Furthermore, a model for Arpa basin has been setup in Mikehydro software. Fine tuning of the model parameters for calibration of the model is in progress (Figure 3).

Figure 3: Mike Hydro Model setup for Arpa Basin

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

Title of Study: **Quantitative assessment of uncertainties in river discharge estimation.**

Study Group - Sanjay Kumar, Sc-D, PI
Sharad Jain, Sc-F, Co-PI

Type of Study- Internal

Start Date - April, 2013

Scheduled date of completion- March, 2016

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).

Statement of the problem:

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.

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

Action plan and timeline:

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 using slope as a parameter (back water effects) (Interim Report-2)						
4	Estimation of uncertainty in stage-discharge (rating) relationship. (Interim Report-3)						
5	Preparation of final report						

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 compution 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.

Progress:

(i) As required by ISO/BIS the NWIP and the working draft of the revised ISO 9123 with updated uncertainty clause has been submitted to BIS/ISO for consideration.
(ii) The working draft of the ISO 9123 has been circulated to SC1 members bodies for call of experts.
(iii) The review comments have been received from experts and currently being resolved.

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

Deliverables: Revised ISO document**,** Research papers and Report

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

Title of the study	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills.
Name of PI, Co-PI, & their affiliation	Dr. Avinash Agarwal (PI), Dr. Manohar Arora (Co PI), RK Nema (PRA)
Type of study	Internal funded
Date of start	Nov. 2013
Schedule date of completion	Nov. 2013 to Oct. 2016 (3 Years)

Role 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 implement-able 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 implement able technology for water availability analysis. Presenting the progress of work when required. Transfer of technology

Sh. R K Nema (PRA): 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

Location of 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.

Objectives of the study:

- Identification and development of river gauging sites. Installation of equipments for long term data base.
- Development of rainfall-runoff-suspended sediment yield model using satellite and general soil information.
- Classification of short and long term springs and development of spring flow model using topographic, hydrologic information such as hydraulic conductivity and effective porosity along with the recession characteristics of fractured soil media.
- Rejuvenation of few selected springs through woven wire check dams/infiltration tanks and to study changes in flow.
- Impact of climatic variability on runoff and spring flows.

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 is measured. The spring flow models will be developed considering topographic and hydrologic information. A long term spring flow record for springs is developed for climatic variability of the springs and for evaluation of spring flow with time.

Recommendation and suggestions in previous meeting of working group

Discussions were held with no specific comment/recommendation. The project was approved.	
▪ .Nil	▪

Analysis of results

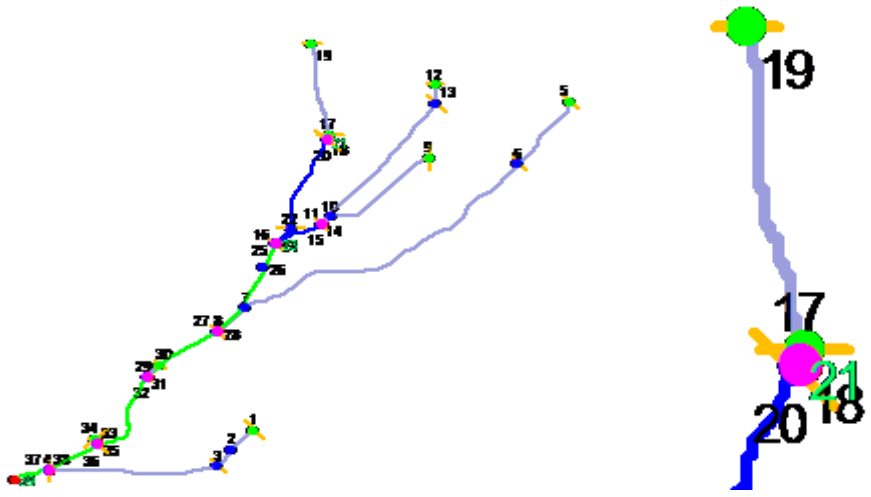
(a) Maintenance and up keeping of installed equipments and data collection.
(b) Spring classification on the bases of spring discharge using Meinzer's classification.
(c) Relative performance of springs by four methods viz. (1) Based on spring flow variability, (2) Based on normalized mass spring flow, (3) Based on rainfall spring flow lag and (4) Based on spring flow gradient.
(d) Spring-shed for the springs of watersheds are defined and the spring-shed area has been estimated.

Results in brief

- **Development of runoff, sediment transport model.**

1. CCH1D model: National Center for Computational Hydroscience and Engineering.
2. Capabilities: Flow, Sediment transport and water quality one dimensional modeling.
3. Input to flow model: Geometry, Bed sediment, Bank sediment, Sediment classification and flow at each input node estimated by SWAT.

Geometry



4. Input files: Bed sediment, Bank sediment, Sediment classification created for the area.
5. Flow at each input green node is to be estimated by SWAT.

List of deliverables	Hydro-meteorological data, papers and report for small watershed of Uttarakhand.
Major items of equipment procured	Nil
Lab facilities used during the study	Nil
Data procured and /or generated	The data hub for the watersheds has been updated.
Study benefits/impacts	Hill habitat, State Government and other agencies.
Specific linkage with institutions and/or end-users/ beneficiaries	Village wise interactive work shops in the watershed are proposed
Shot comings/ difficulties	Nil
Future plan	Model development

6. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-15

1. Title of the Project: **Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P.**

2. Thrust Area under XII five year Plan: Integrated Water Resources Development & Management

3. Project Team: Dr. J.V.Tyagi, Sc 'G', SWH Div. (PI)
Dr. YRS Rao, Sc 'F', DRC, Kakinada (Co-PI)

4. Objectives of the study:

(i) To calibrate and validate SWAT model on Yerrakalva pilot basin
(ii) To compute water balance components of the hydrologic cycle for the basin

5. Statement of the problem:

Under 12th five-year plan program, NIH has taken up Pilot Basin Studies (PBS) for Integrated Water Resources Management (IWRM) in Yerrakalva river basin in coastal Andhra Pradesh. The program involves detailed studies on various components of the hydrologic cycle including water balance study of the basin. A water balance study quantifies the components of the hydrologic cycle at the catchment scale. The components of water balance of a basin are influenced by climate, the physical characteristics of the watershed such as morphology, land use and soil. Therefore, understanding the relationship between these physical parameters and hydrological components are very essential for integrated water resources management. This provides the most fundamental information about the hydrology of a watershed and is necessary to assess the importance of climate and land cover in determining water availability. In addition to providing a baseline understanding of the hydrologic processes occurring within a catchment, the water balance components can be compared over long periods of time to track the hydrologic response of a catchment to climatic and land cover variability. Therefore, the present study has been taken up for estimation of water balance and water yield in Yerrakalva river catchment which is critical to long term sustainable management of water resources in the basin.

6. Study area:

The Yerrakalva river rises in the eastern slopes of the eastern ghats at the boarder of West Godavari and Khammam districts. It enters into West Godavari district after 6.4 km run in Khammam district and runs in West Godavari district for about 180 km and joins the Upputeru river, which takes off from the Kolleru lake and falls into Bay of Bengal. Yerrakalva enters the Godavari western delta near Nandamuru aquiduct of Tadepalligudem Mandal. The catchment area of the river is 2725.03 Sq km of which 2330.10 Sq km spreads in upland and 394.93 Sq km in delta (Fig. 1). The study area gets rain during both Southwest and Northeast monsoons. The annual normal rainfall in the basin is around 1078mm.

7. Present state of art:

Major hydrological processes can be quantified with the help of water balance equations. Since the hydrologic processes are very complex, watershed models are widely used for proper comprehension of water balance components. The models based on explicit catchment water balance modelling are numbered in the hundreds and new models are still being presented. The watershed models partition rainfall into various hydrological processes such as surface runoff, evapotranspiration, percolation, lateral flow and base flow etc. with the constraint to account for all water entering, leaving and being stored in a catchment. This adaptation of the principle of conservation of mass constrains the potential for error.

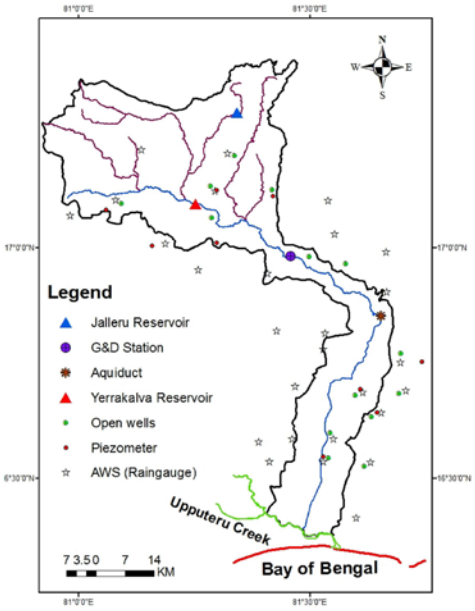


Fig. 1: study area

8. Methodology

SWAT, one of the most recent models developed by the USDA, will be used to analyse and quantify the water balance of the Yerrakalva river basin. The model has been chosen as SWAT is an integrated river basin scale, physically based, continuous-time, long-term simulation, distributed watershed model. Also, its suitability to different parts of the world has been well established. The SWAT model uses physically based inputs such as weather variables, soil properties, topography, land use characteristics and land-management practices occurring in the catchment. In SWAT, a basin is delineated into sub-basins, which are then further subdivided into HRUs based on the homogeneous land use, soil types and topographical characteristics. The major components of SWAT can be grouped into two categories (i) land phase of the hydrologic cycle that controls the amount of water, sediment, nutrient and pesticide loadings to the main channel in each sub-basin, and (ii) routing phase of the hydrologic cycle that defines the movement of water, sediments, etc. through the channel network of the watershed to the outlet. The physical processes associated with water flow, sediment transport, crop growth, nutrient cycling, etc. are directly modelled by SWAT. The hydrologic cycle as simulated by SWAT is based on the water balance equation. Model outputs all water balance components (surface runoff, evaporation, lateral flow, recharge, percolation, sediment yield, etc.) at the level of each watershed and are available at daily, monthly or annual time steps.

9. Work schedule:

(a) Probable date of commencement of the project: April 2014
(b) Duration of the project: One year
(c) Stages of work and milestone:

S. No.	Work Element	1st Qtr 2014	2nd Qtr 2014	3rd Qtr 2014	4th Qtr 2014	Status
1.	Collection of daily hydro-meteorological data & Processing					

2.	Field experiments, collection of soil samples and lab analysis					
3.	Preparation of spatial data base for SWAT viz. DEM, soil map and land use map					
4.	Preparation of attribute data base					
5.	Setting up of SWAT model					
6.	Calibration and validation of model					
7.	Analysis of model output and water balance					
8.	Report preparation					

10. Progress

The daily rainfall data of the study area have been collected. Soil samples have been collected from the field and are being analyzed in the lab for determination of soil texture. Spatial maps viz. DEM, soil map and land use map have been prepared for the study area. Preparation of attribute data for the SWAT model is in progress.

11. Cost estimates

(a) Total cost of the project: Rs. 1,50,000/-
(b) Source of funding: Internal (Plan funds)
(c) Subhead-wise abstract of the cost:

S. No.	Sub-head	Amount (Rupees)
1.	Salary	-
2.	Travelling expenditure	1,00,000/-
3.	Infrastructure/equipment	-
4.	Experimental charges	25,000/-
5.	Misc. Expenditure	25,000/-
	Grand Total	**1,50,000/-**

(d) Justification for the subhead-wise abstract of the cost: Travelling expenditure of Rs. 1,00,000/- is required for field visits of PI, Co-PI and staff of DRC Kakinada to the study area and for data collection from the field departments. Also, some field experiments and collection of soil samples will be carried out for determination of model parameter values.

12. Research Outcome from the project:

(i) Quantification of water balance components of the catchment
(ii) Long term average estimates of catchment water yield
(iii) Technical publications in the form of report and research paper

7. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-15

Title of the study : Systematic treatment and analytical solutions for surges and bores in rectangular channels (Research Study)

Study group Sushil K. Singh**,** Scientist F

Date of start of study 01 April 2014

Duration and scheduled date of completion of study 01 Year; 31 March 2015

Type of study Internal/no additional funding

Objectives of study

1. To develop analytical equations/solutions for surges and bores in rectangular channel avoiding the trial and error solution, with systematic treatment of surges.
2. To illustrate and demonstrate the practical application of the developed analytical equation for solving hydrologic/hydraulic problems concerning surges and bores in rectangular channel to pass a suddenly increased discharge.

Statement of problem and brief methodology

Solution to problems concerning abrupt change in discharge is required to deal with the surges and bores in channels. In this case a forth degree equation is required to be solved.

The objective is intended to be accomplished by analytically solving the required equation for the sudden change in discharge in a channel with a surge or bore moving upstream or downstream.

Achievement/progress: The derivation of the analytical solution is complete. The report writing is in progress.

Outcome:

1. Handy analytical equations for easy and direct computation of the depths of flow in the cases of a positive bore or surge moving upstream or downstream.
2. It will be helpful in practical studies dealing with the open-channel flows, especially in the cases of abrupt change in the depth of flow and in the cases of abrupt changes in discharge (i.e., a bore or a surge).

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

Deliverables

Research report detailing the developed equation and research papers in International Journals.

8. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-15

Title of the study : **Status Report on "Impact of Anthropogenic and Climate Change on Sediment Load of Rivers"**

Name of the PI : Dr Archana Sarkar

Type of Study : Internal

Date of start : 1 April 2014

Scheduled date of completion : 31 March 2015

Study objectives

1. Literature review
2. Preparation of status report

Statement of the problem

The sediment load of a river represents a key component of its hydrology, and in turn exerts an important influence on its aquatic ecology, its morphology and the exploitation of its water resources. Changes in the sediment loads of rivers can therefore have wide-ranging environmental and social and economic implications. There is growing evidence (reported by various authors for different rivers of the world) that the sediment loads of many rivers of the world, especially Asian rivers have changed significantly in recent years due to many reasons, including anthropogenic as well as climate change impact). Therefore, it is required to carry out a comprehensive up to date review of all such studies and prepare a status report.

Approved Action Plan and Timeline

Year	April - June	July-Sept	Oct-Dec	Jan-March
2014-15	Literature Review	Literature Review	Literature Review	Preparation of status report

Progress

Objectives	Achievements
April 2014- October 2014	
1 Literature Review	Completed

RECOMMENDATIONS/suggestions in previous meetings of Working Group/TAC/GB

Refer a status report on Sediment Erosion completed by the division earlier.

Analysis and Results

Review of literature from research papers, reports and books is in progress.

Expected Adopters
State Water Resources Dept and other agencies.

Deliverables
Status report

Data Procured and/generated during the Study
N.A.

Future Plan

As per the approved action plan.

9. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-16

Title of the study :Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State

Name of the PI & Co-PI : Dr. Archana Sarkar, Sc C, SWHD (PI)
Sh. N.K. Bhatnagar, PRA, SWHD
Dr. Vaibhav Garg, Sc C, IIRS, Dehradun
Dr. Rakesh Kumar, Sc G & Head, SWHD

Type of study Internal

Date of start April 2014

Scheduled date of completion 1 March 2016

Study area

Uttarakhand is a state in the northern part of India. It is often referred to as the "Land of the Gods" due to the many holy Hindu temples and pilgrimage centres found throughout the state. Uttarakhand is known for its natural beauty of the Himalayas, the Bhabhar and theTerai. It borders the Tibet Autonomous Region on the north; the Mahakali Zone of the Far-Western Region, Nepal on the east; and the Indian states of Uttar Pradesh to the south and Himachal Pradesh to the northwest. The state is divided into two divisions, Garhwal and Kumaon, with a total of 13 districts. Two of the most important rivers in Hinduism originate in the region, the Ganga at Gangotri and the Yamuna at Yamunotri.

Uttarakhand has a total area of 53,484 km², of which 93% is mountainous and 65% is covered by forest. Most of the northern part of the state is covered by high Himalayan peaks and glaciers. Uttarakhand lies on the southern slope of the Himalaya range, and the climate and vegetation vary greatly with elevation, from glaciers at the highest elevations to subtropical forests at the lower elevations. The highest elevations are covered by ice and bare rock. Below them, between 3,000 and 5,000 metres (9,800 and 16,400 ft) are

the western Himalayan alpine shrub and meadows. The temperate western Himalayan sub-alpine conifer forests grow just below the tree line. At 3,000 to 2,600 metres (9,800 to 8,500 ft) elevation they transition to the temperate western Himalayan broadleaf forests, which lie in a belt from 2,600 to 1,500 metres (8,500 to 4,900 ft) elevation. Below 1,500 metres (4,900 ft) elevation lie the Himalayan subtropical pine forests. The Upper Gangetic Plains moist deciduous forests and the drier Terai-Duar savanna and grasslands cover the lowlands along the Uttar Pradesh border in a belt locally known as Bhabhar. These lowland forests have mostly been cleared for agriculture, but a few pockets remain.

In June 2013, several days of extremely heavy rain caused devastating floods in the region, resulting in more than 5000 people missing and presumed dead. The flooding was referred to in the Indian media as a "Himalayan Tsunami".

Objectives of the Study

1. Procurement of additional rainfall data of the available rain gauge stations in Uttarakhand State from various agencies and processing of rainfall data.
2. Spatio-temporal trend analysis of historical rainfall data.
3. Downloading and processing of rainfall data (same location as that of rain gauge stations) from TRMM satellite data as well as high resolution gridded re-analysis rainfall data from APHRODITE.
4. Comparison of rainfall data from various sources.

Statement of the Problem

Study of rainfall based on an integrated perspective of its attributes like spatio-temporal variation, persistence, trends, periodicities etc is very essential for understanding the nature of weather and climate patterns. A good knowledge of local rainfall-regime is crucial for planning and management of domestic, urban as well as industrial water use, irrigation and crop practices besides forecasting and management of extreme events like floods and droughts. In view of the recent flood disaster in the Uttarakhand state, it becomes all the more important to carry out a scientific analysis of the rainfall regime of the region.

Rainfall observations are an essential element of studies related to hydrological processes.They are utilized both for a better understanding of these processes and as input in hydrological simulation models indispensable to a correct territorial planning and to an adequate management of water resources system. Rain gauges, radars, satellite sensors, forecasts from high resolution numerical weather prediction models and high resolution gridded re-analysis rainfall data are a part of precipitation monitoring networks/data sources. These data sources provide rainfall data that are further provided to hydrological models to produce forecasts, therefore, their comparative accuracy assessment is of prime importance.

Approved Action Plan and Timeline

Year	April - June	July-Sept	Oct-Dec	Jan-March
2014-15	Additional rainfall data procurement, data processing	Additional rainfall data procurement, data processing	Trend Analysis of historical rainfall data	Interpretation of results and preparation of interim report

2015-16	Downloading of TRMM satellite data and APHRODITE data	Processing of downloaded data	Analysis and comparison of data from different sources	Interpretation of results and preparation of final report

Progress

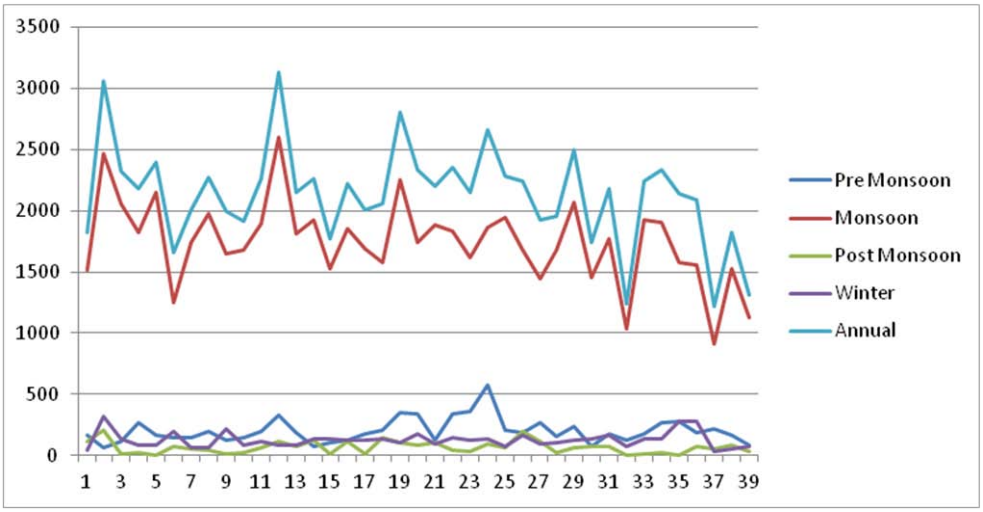
Objectives	Achievements
April 2014- October 2014	
1. Additional rainfall data procurement, data processing	Completed
2. Trend Analysis of historical rainfall data	In progress

RECOMMENDATIONS/suggestions in previous meetings of Working Group/TAC/GB
Nil

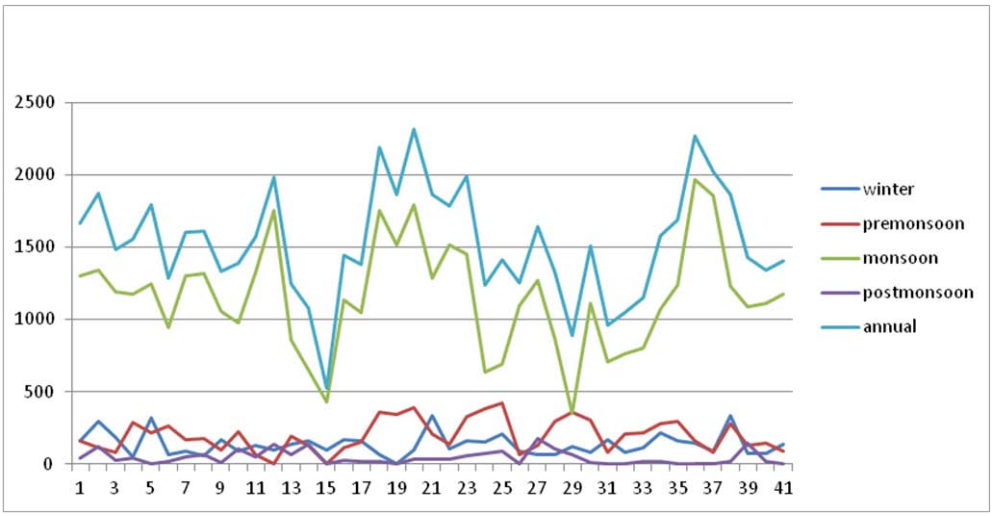
Analysis and Results

Data Used
Daily/monthly rainfall data of varying length at 50 stations in Uttarakhand. However, long term data required for statistical trend analysis (minimum 30 years) was available at only five stations (Mukhim, Dehradun, Mukteshwar, Dharchula and Roorkee) with very little missing data which was filled with standard methods. Other stations data showed large missing data and were unable to process for continuous series.

Results
Data processing at five stations namely, Mukhim, Dehradun, Mukteshwar, Dharchula and Roorkee has been carried out and annual, monthly and seasonal rainfall series have been prepared for all these stations. Time series plots for two stations are shown below.



Rainfall time Series at Dharchula (Kumaon Region)



Rainfall time Series at Mukhim (Garhwal Region)

Expected Adopters

State Water Resources Dept and other agencies.

Deliverables

Research papers and report

Data Procured and/Generated during the Study

Daily rainfall data at 50 raingauge stations around Uttarakhand State with varying length.

Future Plan

As per the approved action plan.

10. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-17

1. Title of the Study: Monitoring and modelling of streamflow for the Gangotri Glacier

2. Study Group : Dr Manohar Arora Sc 'C'
Dr Rakesh Kumar Sc 'G'

Role of Team Members:

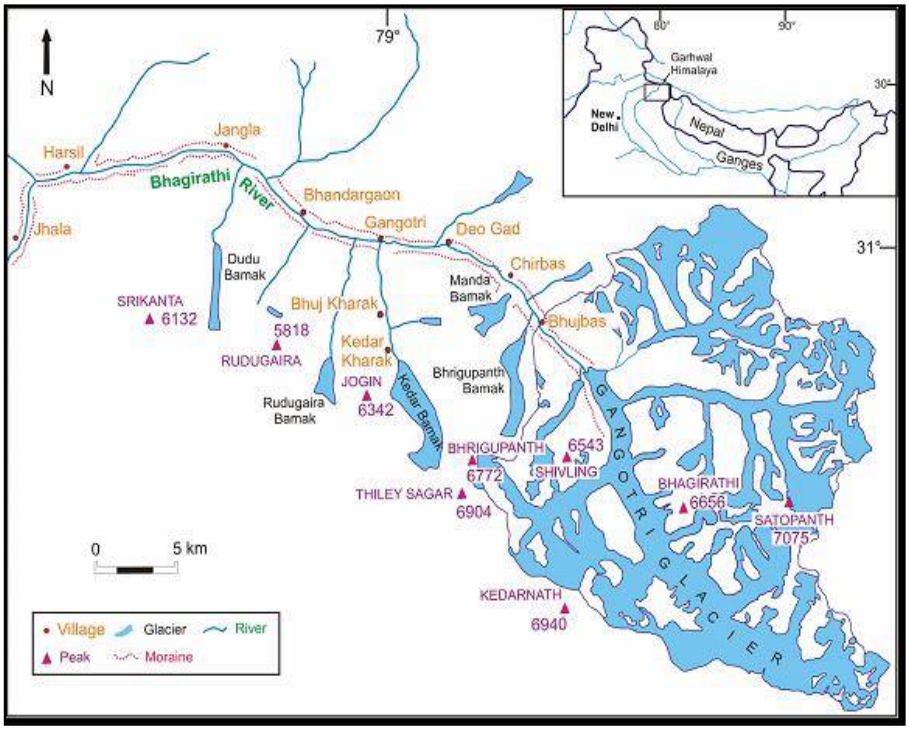
1. **Dr. Manohar Arora, Scientist C & PI:** Conduction field investigations, analyzing data/information, report preparation and overall responsible for the study completion.
2. **Dr. Rakesh Kumar, Scientist G &** Co-PI: Guidance in development of methodology, modelling and structuring of report.

3. Type of Study : Sponsored

4. Date of start : 01.5. 2014

5. Scheduled date of completion : 31.03.2017

6. Location Map:



7. Objectives: The objective of this study includes:

- Continuous observations of meteorological, hydrological and suspended sediment data for the melt season to determine monthly and seasonal specific water and sediment yield from the study glacier.

- To study the melt water storage and drainage characteristics of the glacier and to simulate daily stream flow using a conceptual hydrological model using observed meteorological and hydrological data.
- Modeling the role of glacier in catchment runoff variation.
- Modeling the catchment runoff variation under different climatic scenarios.

8. 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. The third step is to model role of glacier in catchment runoff variation and catchment runoff variation under different scenarios.

Approved action plan:

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

Objectives vis a vis Achievements:

Objectives	Achivements
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 2014 have been collected. The team had returned successfully on 17th October 2014
To study the melt water storage and drainage characteristics of the glacier and to simulate daily streamflow using a conceptual hydrological model using observed meteorological and hydrological data.	The objective is studied with the previous three years data of 2007, 2008 & 2010. It is observed that in the early stages of the ablation period, poor drainage network and stronger storage characteristics of the glaciers due to the presence of seasonal snow cover resulted in a much delayed response of melt water, providing a higher t_l and t_p. In the beginning of melt season, the night time flow is almost equal to day time flow, but in the later part of the melt season, night time flow is slightly lower than the day time flow. This analysis suggests that storage characteristics are much stronger in the early part of melt season and reduce as the melt season progresses. A comparison of runoff delaying parameters with discharge ratio clearly indicated that changes in time-lag and time to peak are inversely correlated with variations in discharge. This will be again investigated with current three years data.

Recommendations of Working Group/TAC/GB:

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

Analysis and Results:

The Department of Science and Technology has sponsored this study. This is the first year and the investigations were started on 17th May 2014.

Adopters of the results of the study and their feedback:

The study is a sponsored study and the results will be disseminated by DST.

List of deliverables:

Major items of equipment procured: Nil

Lab facilities during the study: Analysis of suspended sediment samples will be carried out in Soil Lab.

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

Study Benefits/Impact: The study is being sponsored by DST. The meteorological and discharge data would be utilised in studying the characteristics of the Gangotri glacier under changing climate.

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.

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.

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.

11. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-17

1. **Title of the study: Effect of climate change on evaporation at point scale**

2. Study Group: Sh. Digambar Singh, Sc B, SWHD
Dr. A. R. Senthil kumar Sc E, SWHD
Dr. Manohar Arora, Sc D, SWHD

3. Date of start: 1 June 2014

4. Duration of the study: 3 Years

5. Whether externally funded or not: No

6. Objectives of the study:

I. To develop evaporation model by empirical and soft computing techniques
II. To downscale the data of temperature, rainfall and humidity from GCM model
III. To determine the effect of climate variables on evaporation by using the downscaled data

7. Brief Methodology:

Evaporation model

Multiple Linear regression (MLR) and soft computing techniques would be applied to model the evaporation with rainfall, temperature and humidity as input vectors.

Development of climate scenarios

The prediction of rainfall, minimum and maximum temperature and humidity for future is possible by considering the statistical properties of the time series. The weather generators, considering the future carbon emissions, radiation and effects of green house gases, have been developed to generate the time series by fitting a distribution to the times series and by using the properties of distribution of the times series. The different scenarios of climatic conditions such as A1F1, B1 and baseline can be obtained from SDSM (**Statistical DownScaling Model)** from UK/PRECIS from IITM, Pune. The best models developed by soft computing techniques to simulate the evaporation from historical values of rainfall, maximum and minimum temperature and humidity at the site can be utilized to generate the evaporation from the generated values of rainfall and maximum and minimum temperature and humidity for different climatic scenarios as mentioned above. The falling and rising values of evaporation from the different climate scenarios would give an idea to the official dealing with the planning of cropping pattern.

8. Results achieved with progress/present status

The literatures related to statistical downscaling from GCM have been reviewed from renowned international journals. The daily data of rainfall, temperature, relative humidity, wind speed and evaporation at NIH observatory are available from 1987 to 2014 and the data have been analyzed for gaps and errors and the same have been removed. The empirical method, modified Penman method, is used to compute the evaporation from the available data. Multiple linear regression model is being developed with the available data to simulate the evaporation.

9. Expected date of completion**: 31 March 2017**

12. PROJECT REFERENCE CODE: NIH/SWD/NIH/14-17

1. **Title of the study:** **Hydrological modelling of Brahmani Baitarani river basin using eWater Source platform**.
2. **Study group:** J. P. Patra, Sc. 'B'; Dr. Rakesh Kumar, Sc. 'G' & Head, Pankaj Mani, Sc. 'D', CFMS, Patna;

   Technical assistance: T. R. Sapra, RA.
3. **Duration of study:** 3 Years (April 2014 to March 2017) : Ongoing
4. **Type of study:** Internal.
5. **Location map**

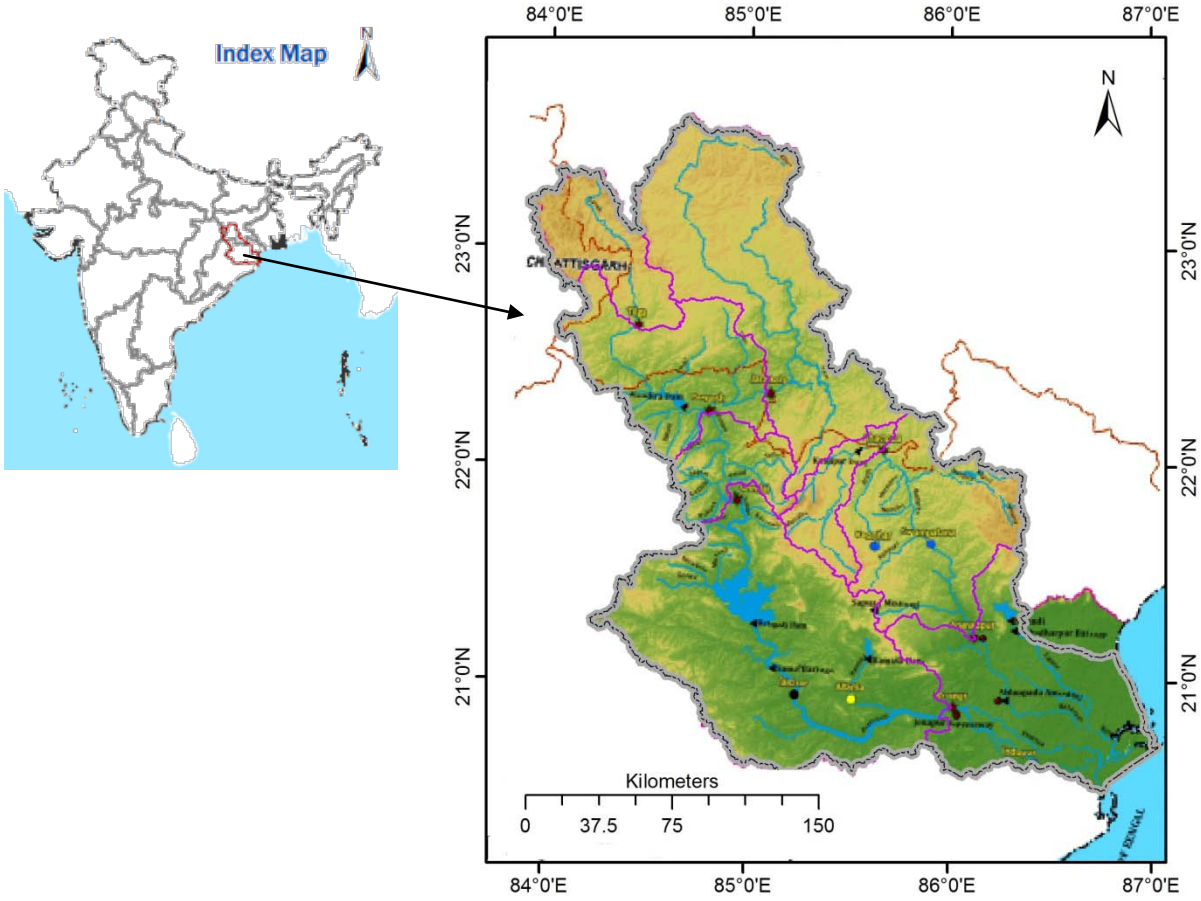


Fig. 1: Location map of study area.

6. **Study objectives:**

   a) Statistical and trend analysis of rainfall and river discharge in Brahmani Baitarani river basin.

   b) Development of rainfall runoff model for Brahmani Baitarani river basin using eWater source platform.

   c) Investigation of implications of different rainfall inputs on rainfall–runoff simulation.

   d) Test the applicability of the eWater source modelling platform in Brahmani Baitarani river basin by generating hydrological time series.

7. Statement of the problem

The eWater source is Australia's first national river basin scale water modelling system. The source modelling platform has been developed to take a holistic approach to water management including human and ecological impacts. This includes integrating policy, addressing water savings and sharing for a whole river and connected groundwater systems including cities, agricultural and environmental demands.

In the India-Australia Water Science and Technology Partnership programme, Australia is collaborating with the Ministry of Water Resources to pilot the source river basin modelling platform in India. The MoWR, GOI is planning to develop an Integrated Water Resources Management (IWRM) plan for Brahmani Baitarani basin using the source river basin modelling platform. Hence, the present study has been formulated to develop a rainfall runoff model for Brahmani Baitarani river basin in source platform and test its applicability by generating hydrological time series.

8. Approved action plan and timeline

Sl. No.	Work Element	1st Year	2nd Year	3rd Year	Status
1	Literature Review and detailed formulation of research approach				Completed
2	Collection of hydro meteorological data, satellite images, thematic maps etc.				Under Progress
3	Compilation, statistical and trend analysis of rainfall and river discharge				Under Progress
4	Rainfall runoff model set up in eWater Source platform				Under Progress
5	Implications of different rainfall inputs and sub catchment size				Yet to start
6	Calibration and parameter estimation				Yet to start
7	Model performance evaluation with in various time periods				Yet to start
8	Reporting	Interim report	Interim report	Final report	Under Progress

9. Role of team members

Sl No	Role / Action	Member/(s)
1	Literature Review and detailed formulation of research approach	JPP, RK, PM
2	Collection of hydro meteorological data, satellite images, thematic maps etc.	JPP, TRS
3	Compilation, statistical and trend analysis of rainfall and river discharge	JPP, RK
4	Rainfall runoff model set up in eWater Source platform	JPP, PM
5	Implications of different rainfall inputs and sub catchment size	JPP, RK
6	Calibration and parameter estimation	JPP, PM

7	Model performance evaluation with in various time periods	JPP, RK
8	Reporting	JPP, PM,RK

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

10. Brief Methodology

The Brahmani Baitarni basin (Fig. 1) extends over states of Odisha, Jharkhand and Chhattisgarh with catchment area of about 51,822 km^2. The basin is bounded by the Chhotanagpur Plateau on the north, by the ridge separating it from Mahanadi basin on the west and the south and by the Bay of Bengal on the east. The Brahmani known as South Koel in its upper reaches rises near Nagri village of Jharkhand at an elevation of about 600 m and has length of about 800 km. In its tail reach, the river is known as Maipura. The Baitarni rises near Dumuria village in the hill ranges of Kendujhar district of Odisha at an elevation of about 900 m and has a length of about 355 km. The river is known as Dhamra in its lower reaches. Brahmani and Baitarni form common delta area before falling into the Bay of Bengal. The lower reaches of the basin near the deltaic area are subject to floods. Moreover Mahanadi, Brahmani and Baitarani are interconnected near their delta, worst flood occur when there is simultaneous heavy rains in all the three catchments. Floods are also caused from cyclonic storms since the coastal areas of the basin are cyclone-prone. The industrial development potential of this basin is very high due to its rich mineral resources (iron ore, copper, bauxite etc.) and power potential (548 MW at 60% load factor). Rourkela is an important industrial centre located in this basin. There various other industries (Iron and steel, Thermal power plant, fertilizers etc) existing the basin and more than 50 small to large industries are planned to set up in the upper and middle reaches of the basin. Hence, in future there will be very high water demands from industrial sectors.

Historical rainfall and flow data of the Brahmani Baitarani river basin will be collected and time series of monthly, seasonal and annual values of rainfall and discharge will be analyzed using statistical methods. Trend analysis will be performed to determine whether or not there have been any significant changes in rainfall and discharge over this catchment. The analogue year's plots will be used to identify years with near normal, above normal and below normal conditions, using the long term mean of the variables.

Rainfall runoff models are used to derive runoff for a particular area from inputs of rainfall and potential evapotranspiration. All rainfall runoff models in source are conceptual models that represent catchment hydrological response to rainfall as a series of mathematical relationships. They provide runoff output from each functional unit as total discharge, which is split into quick flow (surface flow) and slow flow (baseflow) proportions. The rainfall-runoff models presently available in source are: Sacramento (sixteen parameters), SIMHYD (7 parameter), SMARG, GR4J (modèle du Génie Rural à 4 paramètres Journalier) (four parameters), IHACRES (six parameters), AWBM (3 parameter), SURM. These models will be configured to run the rainfall-runoff models at the catchment scale.

Different methods are available to obtain the daily rainfall time series for conceptual rainfall–runoff models, depending on data availability, time constraints etc. The implications of different rainfall inputs on the calibration and simulation of rainfall–runoff models will be analysed. First, the simulated runoff resulting from single lumped daily rainfall series for each catchment obtained from three methods: single rainfall station, thiessen average, and average of interpolated rainfall surface will be compared. Secondly, runoff generated from catchment modelling using daily/monthly rainfall series and modelling with smaller functional units within a sub catchment will be compared. The source platform includes set of optimisation tools for calibration of various model parameters. These high-level optimisation features include: Shuffled Complex Evolution (SCE-UA), multi-objective complex evolution (MOCOM-UA), Rosenbrock and other optimisation algorithms; predefined and user defined

custom objective functions; option for custom optimisation problems such as regional calibration. Some of these techniques will be applied to calibrate the model. Finally, the calibrated model will be used to simulate hydrological time series for various time periods and will be compared with observed time series to test the applicability of the eWater source modelling platform in Brahmani Baitarani river basin.

11. Results achieved with progress/present status

During the past six months the major time was devoted for literature review, collection of hydro meteorological data, satellite images, thematic maps etc. and compilation of rainfall and river discharge data. The details of data collected are given in a separate heading. The rainfall and discharge data are analysed for missing value and various statistical properties are calculated.

12. Action taken on comments of previous working group meeting

There were no specific comments.

13. List of deliverables

- Water availability at various river reaches and sub catchments
- Applicability of the eWater source modelling platform in Brahmani Baitarani river basin,
- The rainfall runoff modelling setup will help in development of IWRM plan in Brahmani Baitarani river basin.
- Papers and reports.

14. Data collected/generated

- DEM of the study area is generated from SRTM.
- Land use and land cover map is generated by classifying LANDSAT image.
- Daily rainfalls for eight raingauge stations are collected from IMD. However the data set is having missing values at some stations.
- Monthly rainfalls for 121 raingauge stations are collected from water resources department of Odisha
- Stage and discharge at thirteen gaugiging sites namely, Akhuapada, Altuma, Anandapur, Champua, Gomlai, Jaraikela, Jenapur, Keonjhar, Panposh, Rengali, Swampatna, Talcher and Tilga from water resources department of Odisha.
- Reservoir characteristics like Elevation Area Capacity table, Monthly evaporation data for 33 reservoir are also collected from water resources department of Odisha.

15. Involvement of end users/beneficiaries

The study has been proposed with reference to the work assigned by MoWR. There has been discussion with the officials of CWC and Odisha water resources department regarding need of the study.

WATER RESOURCES SYSTEM DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2014-2015

SN	Title	Study Team	Duration	Funding (Rs. in Lakhs)
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)	NIH
2.	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Sharad K. Jain DeepaChalisgaonkar Prabhash K. Mishra	2 Years (04/13-03/15)	NIH
3.	Web GIS based snow cover information system for the Indus Basin	D. S. Rathore DeepaChalisgaonkar L. N. Thakural Tanvear Ahmed	2 Years (04/13-03/15)	NIH
4.	Assessment of Water Footprint of the National Capital Territory (NCT) of India	DeepaChalisgaonkar Sharad K. Jain M. K. Nema P. K. Mishra	2 Years (04/13-03/15)	NIH
5.	Assessing climate change impact across KBK region of Odisha	P. K. Mishra Sharad K. Jain Sanjay K. Jain	2 Years (04/13-03/15)	NIH
6.	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain Sharad K. Jain Renoj J. Thayyen	2.5 Years (10/13-03/16)	NIH
7.	Variability of the Hydro-climatic variables in Punjab Plains of Lower Satluj	M. K. Nema Sharad K. Jain	2 Years (11/13-10/15)	NIH (11.34)
8.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S P Rai Sanjay K Jain Sudhir Kumar	3 years (04/14-03/17)	NIH (20)
9.	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain M. K. Goel Sanjay K. Jain Tanvear Ahmed	2 -3/4 Years (06/14-3/17)	NIH (23)
10.	Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra	D. S. Rathore M. K. Goel, R.P. Pandey Sanjay Kumar Surjeet Singh	2 years (07/14-06/16)	NIH (34)
Ongoing Sponsored Studies				
1.	Glaciological studies of Phuche Glacier, Ladakh Range, India	Renoj J. Thayyen M K Goel S P Rai	5 Years 1/10-12/14	DST (56)
2.	Assessment of Environmental flow for Himalayan River	Sharad K. Jain Pradeep Kumar P. K. Agarwal P. K. Mishra	1 Year 12/14-12/15	MOES (8.61)

Proposed New Internal Studies				
1.	Modeling of Narmada basin by using the GWAVA model	Sanjay K. Jain Sharad K. Jain T. Thomas (RC-Bhopal) P. K. Mishra P. K. Agarwal M. Nema	2.25 years Dec. 2014 – Mar 2017	NIH
2.	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years Dec-2014 to Nov.2017	NIH
3.	Hydrological process and characterization of Lesser Himalayan Catchments	Sharad K. Jain Sanjay K. Jain Renoj J. Thayyen P. K. Mishra M. Nema P. K. Agarwal	5 years Dec.-14 to Dec.-19	NIH +

INTERNAL RESEARCH PROJECT: NIH/WRS/2011/01

Title of Study	**-**	**Trend and variability analysis of Rainfall and Temperature in Himalayan region**
Study Group	**-**	Mr**.** L. N. Thakural, Sc-B, PI Dr. Sanjay Kumar, Sc-D, Co-PI Dr. Sanjay Kumar Jain, Sc-F, Co-PI Dr.Sharad Kumar Jain, Sc-G, Co-PI Mr. Tanveer Ahmed, Sc-B, Co-PI
Type of Study	**-**	Internal
Start Date	**-**	October 01, 2011
Scheduled date of completion	**-**	September 30, 2014
Location/Study area	**-**	Himalayan region

Objectives of the study:

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

Statement of the problem:

Climate change due to global warming has impacted the water resources sector in different manner. In recent decades this issue is of major concern for the hydrologist, water resources executives and the administration. Variation in the temperature has significantly affected the rainfall patterns. The water resources of a area is mainly dependent on the rainfall which is available as streamflow required for various activities such as agriculture, designing of water resource and river valley projects etc. Thus, it is of great importance to study the trends in the hydro-meteorological variables.

Methodology:

Statistical techniques/tools have used to evaluate the temporal and spatial characteristics of the rainfall and temperature time series. As meteorological data in the Himalayan region is scarce, therefore rainfall data from APHRODITE have been also used for analysis. The trends and variability analysis of rainfall and temperature have been evaluated using parametric and non-parametric.

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		

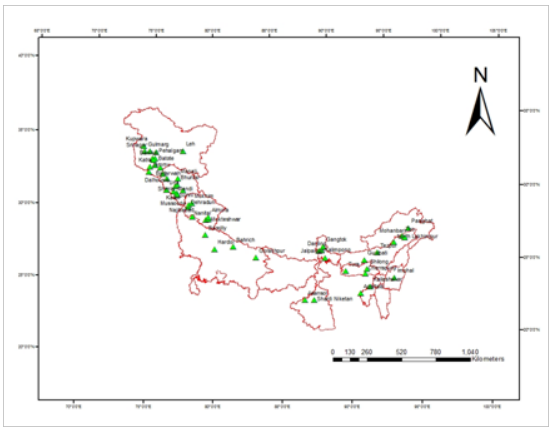
Achievements

Year	Objectives (June-October 2014)	Achievements
2014	Analysis for Western Himalayan region	Parametric and non-parametric approaches have been applied to detect trend in temperature and rainfall.

Recommendations / suggestions in previous WG- Nil

Analysis and Results

The present study area covers the western, central and eastern part of Himalayas. The Indian Himalayan region is a range that spans in States of India namely Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram and Tripura as well as the hill regions of two states - Assam and West Bengal.



Location map of study area

Trends in Temperature

The magnitude of the trends in the mean temperature on monthly, seasonal and annual time scale is determined using the Sen's slope estimator. The results for monthly scale are shown in Table 1 and for seasonal and annual time scale in Table 2. The Man-Kendall test was applied to this time series to ascertain the significance of trends (Table 1and 2).

Table 1: Sen's estimator of slope (^{0}C/year) for monthly average temperature

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Asansol	.002	.015	-.003	.013	.013	-.005	.010	.013	.002	.015	.017	.006
Darjeeling	**.013**	**.010**	**.012**	.006	**.010**	**0**	**-.003**	**.000**	**.003**	**.022**	**.027**	**.020**
Kalimpong	**.011**	**.023**	-.001	**.006**	.015	**.007**	.001	.010	.025	**.054**	**.030**	**.010**

Jalpaiguri	**0**	.007	.010	.005	-.007	**-.015**	**-.019**	**-.013**	**-.009**	-.003	**0**	**.009**
Gangtok	-.033	-.050	-.019	-.019	**0**	**.004**	**-.017**	**-.004**	**-.010**	**-.005**	**-.008**	**-.012**
Shanti Niketan	-.015	-.010	.001	-.021	-.017	-.007	.011	.012	.004	.022	.032	.016

Table 2: Sen's slope (^{0}C/year) for seasonal and annual mean temperature

Station	Pre-monsoon	Monsoon	Post-monsoon	Winter	Annual
Asansol	.008	.006	.016	.007	.009
Darjeeling	.000	**.001**	**.025**	**.015**	**.010**
Kalimpong	**.004**	.008	**.038**	**.023**	**.011**
Jalpaiguri	.002	**-.014**	**-.001**	**-.005**	**-.003**
Gangtok	**-.019**	**-.007**	**-.008**	**-.019**	**-.018**
Shanti Niketan	-.013	.005	**.025**	-.004	.002

Bold indicates statistical significance at 95% confidence level

The results reveal that post-monsoon temperature indicated a significant increasing trend at Shanti Niketan station. The increasing trends were observed at Darjeeling during monsoon, post-monsoon, winter, and also annually. Kalimpong showed significant increasing trends during pre-monsoon, post-monsoon, winter as well on annual scale. The significantly decreasing trend was observed at Jalpaiguri station during monsoon, post-monsoon, winter and annually. Gangtok is the only station, experiencing significant decreasing during all the seasons as well as annually.

The monthly, seasonal and annual temperature at Asansol station did not show any significant decreasing or increasing trend whereas Darjeeling experienced significantly increasing trends almost at all scales except during pre-monsoon in which is found to be stable and negative trend in the month of July.

Trends in Rainfall

The magnitude of the trends in the annual mean rainfall time series on seasonal and annual time scale is determined using the Sen's slope estimator is given in Table 3. The Man-Kendall test was applied to this time series to ascertain the significance of trends (Table 3).

Table 3: Sen's estimator of slope (mm/year) for seasonal and annual rainfall

Station	Pre-monsoon	Monsoon	Post-monsoon	Winter	Annual
Asansol	.008	.006	.016	.007	.009
Darjeeling	.000	**.001**	**.025**	**.015**	**.010**
Kalimpong	**.004**	.008	**.038**	**.023**	**.011**

Jalpaiguri	.002	**-.014**	**-.001**	**-.005**	**-.003**
Gangtok	**-.019**	**-.007**	**-.008**	**-.019**	**-.018**
Shanti Niketan	-.013	.005	**.025**	-.004	.002

It can be seen from Table 3 that Jalpaiguri experiences statistically decreasing trend in all seasons except pre-monsoon. The trends at Kalimpomg station showed significant increasing trend during all seasons except monsoon.. During monsoon season Jalpaiguri and Gangtok experienced decreasing trends whereas Darjeeling experiences increasing significant trends

Adopters of the results of the study

Different departments such as Water resources, agriculture, and administrative executives.

Study benefits/impacts

The changes in temperature, precipitation, and other climatic variables are likely to influence the amount and distribution of runoff in all river systems globally. The detection of trends and magnitude of variations due to climatic changes in hydro climatic data, particularly temperature and precipitation is essential for the assessment of impacts of climate variability and change on the water resources of a region. The results will be useful for the runoff and climate change studies.

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INTERNAL RESEARCH PROJECT: **NIH/WRS/2013/02**

Thrust area under XII five year plan: Integrated Water Resources Development & Management

Title of Study - *NIH_Basin* – A WINDOWS based model for water resources assessment in a river basin

Study Group - M. K. Goel
Sharad K. Jain
DeepaChalisgaonkar
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 model is under continuous stage of development. Since the last working group, efforts have been made to make a number of modifications in the model methodology and software program.

For approximating the EAC relationships for a reservoir, the approach developed by J. Mohammadzadeh-Habiliet. al. (2009) has been adopted. This method avoids the necessity of specifying EAC tables for various reservoirs in the river basin. The method has been programmed within the FORTRAN code of the model.The previous option of assuming a triangular distribution has also been retained.

Rule-curve based approach has been added in the FORTRAN code for simulating the reservoir operation as per specified operation policy. Earlier, reservoir operation was simulated only with standard linear operation policy (SLOP) only. The option of hydropower simulation of a reservoir has also been added and eight different methods of supply of water through the power plants have been considered. Tail water elevation is also considered as a function of discharge.

It is now planned to provide two versions of the model: a) monthly mode (in which the simulation is carried out at daily time step for a month and then the spatial recharge and discharge pattern are externally used to find the revised water table in the basin with some groundwater simulation model, say Visual MODFLOW, and the revised groundwater table is used for the subsequent month), and b) continuous mode (in which the simulation is carried out at daily time step for the complete period for which hydro-meteorological data are available). In the second mode, grid-wise pumping and recharge estimations are accumulated over each sub-basin and then divided by the S_y of sub-basin to convert water withdrawal/ recharge to corresponding change in groundwater level which can be applied to initial groundwater surface to find the revised surface in the sub-basin, thus avoiding the necessity of detailed groundwater simulation. For each sub-basin, average groundwater depth is computed from data of a large number of observation wells (a procedure, defined by DHI, Denmark has been adopted for converting irregular observations in different wells in a sub-basin) has been programmed and will be added as a module in the software.

In WINDOWS interface of the model, various data input forms have been developed and some are under progress along with modifications in modeling methodology.

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 at basin scale.

Deliverable

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

* * *

INTERNAL RESEARCH PROJECT: NIH/WRS/2013/03

Title of study - **Web GIS based snow coverinformation 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 years

Objective:

To develop methodology for snow cover mapping

The objective of the study is to publish snow cover information on web as an OGC web servicefor 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 through web services.

Location map/study area

Indus basin

Approved action plan and timeline:2013-14/14-15

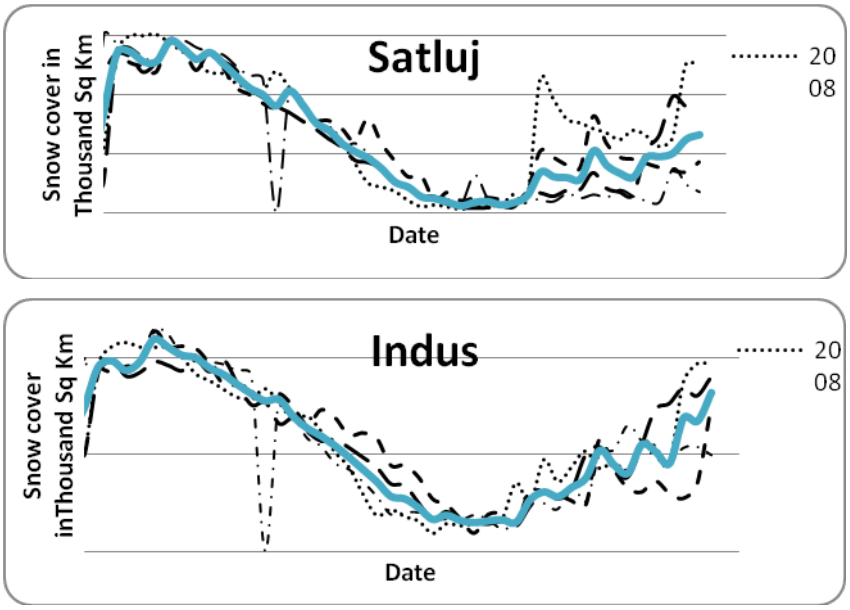
1st quarter	2nd quarter	3rd quarter	4th quarter
Download of data	Processing of the data	Preparation of WebGIS application	Writing of report

Recommendations / suggestions in previous WG

None

Achievements

Year	Objectives	Achievements
2014-15	To develop methodology for snow cover mapping To publish snow cover	NDSI, Reflectance NIR were used to delineate snow. FCC were visually inspected to identify cloud cover and snow area of cloud free scenes of preceding or succeeding dates were used for these scenes. MYD09A1 data were downloaded for years 2010-2012.

	information on web as an OGC web servicefor Indus basin	Data were processed using snow delineation criteria. The Web GIS application was developed.  Fig. Snow cover area for Satluj and Indus

Data procured and generated during the study:

Satellite data downloaded

- MYD09A1 (2010-2012)

Data generated

Snow maps, depletion curve for Indus basin/ sub basins (2010- 2012).

INTERNAL RESEARCH PROJECT: NIH/WRS/2013/04

Title of Study	-	**Assessment of Water Footprint of the National Capital Territory (NCT) of India**
Study Group	-	Mrs D Chalisgaonkar Dr Sharad K Jain Er Manish K Nema Er Prabhash K Mishra
Type of Study	-	Internal
Start Date	-	April 01, 2013
Target date of completion	-	31st March, 2015

Objectives

The objective of this study is to estimate the water footprints of NCT Delhi from both a supply and consumptionperspective by quantifying green, blue and grey water footprints. Additionally, the aim is to understand how the water resources of NCT Delhi are being utilized for water consumption.

Methodology

The methodology used in this study is largely based on earlier studies supported by Water Footprint Network (www.waterfootprint.org). There are three components of water footprint.

Blue Water Footprint:

It is the volume of surface water and groundwater consumed (i.e. evaporated or incorporated into the product) during production processes.

Green Water Footprint

It is the volume of rainwater consumed (i.e. evaporated or incorporated into the product) by the product; and

Grey Water Footprint

It is the amount of freshwater required to mix pollutants and maintain water quality according to agreed water quality standards.

In the present study, theprevious methodologiesare integrated and upgraded where possible. The main upgrades are the incorporation andassessment of green, blue and grey water resources.

The study of existing water management schemes of water supply and sewage treatment of NCT Delhi reveals the following activities influence the water use within the city boundary:

- Sources of Water in NCT Delhi

- Consumption of water for various purposes
- Processing at a sewage treatment plant

The water footprints thus consist of two components: consumptive water use and wastewater pollution. The impact of water pollution is being assessed by quantifying the dilutionwater volumes required to dilute waste flows to such extent that the quality of the waterremains below agreed water quality standards. The water footprint of NCT Delhi is being assessed for three major sectors i.e. domestic, agriculture and industrial.

The WF of the NCT Delhiis being computed based on the data for the period 2006-2010 collected from various sources, published reports from various departments of government of NCT Delhi and from some other important websites. The virtual water content related data is available at country level not at NCT Delhi level, so it is being used for NCT Delhi as well. The data which was not available has been assumed.

The WF is being computed based on the available data of direct (real) and indirect (virtual) water consumption of NCT Delhi. As the computation of grey water footprint includes the amount of freshwater required for mixing pollutants and maintaining water quality according to agreed water quality standards, the water quality criterion of Central Pollution Control Board ('C' Class water), given below, has been taken as the water quality standards for the computation of dilution water requirement.

'C' CLASS WATER QUALITY NORMS

Drinking water source after conventional treatment and disinfection	• Total Coliforms Organism MPN/100ml shall be 5000 or less • pH between 6 to 9 • Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less

Progress of the Study:

The assessment of the domestic water footprint has been done as a first step during 2013-14. It has been done by computing the environmental pressure exerted by the population of NCT Delhi in terms of the water it uses directly and indirectly. The assessment of agriculture water footprint has been taken up and industrial water footprint will be assessed in the next step.

For the computation of crop water requirement, CROPWAT software is being used. It uses precipitation data, crop growth inputs, and soil data to calculate crop water requirements.CROPWAT is a decision support tool developed by the Land and Water Development Division of FAO. After all yields and variables in the CROPWAT program are accounted for, the blue and green water footprints can be determined.

Green water use by crop = min (crop water requirement, effective precipitation)

Blue water use by crop = min (irrigation requirement, effective irrigation)

The grey water component will be calculated based on the application of Nitrogen (N) fertilizer to the crop fields. Only the Nitrogen fertilizer use will be incorporated into the grey water footprint, because the grey component is expressed as a dilution water requirement. This means only the most critical pollutant with the greatest application rate need be considered.

Virtual water import component is also being considered for the computation of agriculture water footprint as lot of agriculture related products are brought in Delhi for consumption. A part from core agricultural activities the forested areas, public parks, big gardens, golf courses, cricket grounds etc. also are being considered for computation of agriculture water footprint of NCT Delhi.

WORK PLAN FOR 2014-15: AGRICULTURE & INDUSTRIAL WATER FOOTPRINT

TASK	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Literature review and conceptualisation				
Data collection and boundary delineation				
Data analysis				
Final report writing				

Benefits of the Study:

- Economic benefits: better water management and better water use have positive impacts on water costs;
- Environmental benefits: better water quality and more efficient water consumption have lower impacts on ecosystem;
- Social benefits: better quality of water means better quality of life;
- An Indian approach on water use: definition of common strategies on water footprint will contribute to promote transnational awareness on domestic water management, saving and innovations.

INTERNAL RESEARCH PROJECT: NIH/WRS/2013/05

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 "G" Dr. Sanjay K. Jain, Sc "F"
Type of Study	-	Internal
Start Date	-	April 01, 2013
Proposed date of completion	-	31st March, 2015

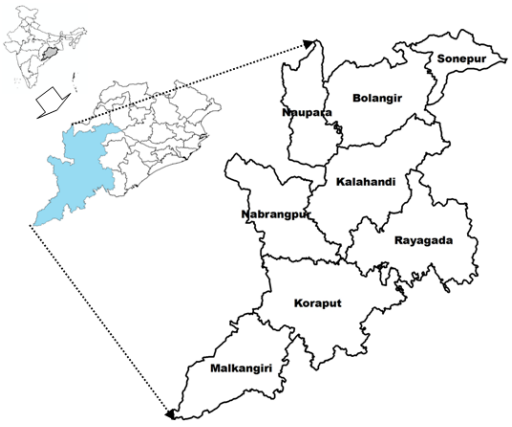
Study objectives:

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 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						

Progress Made:

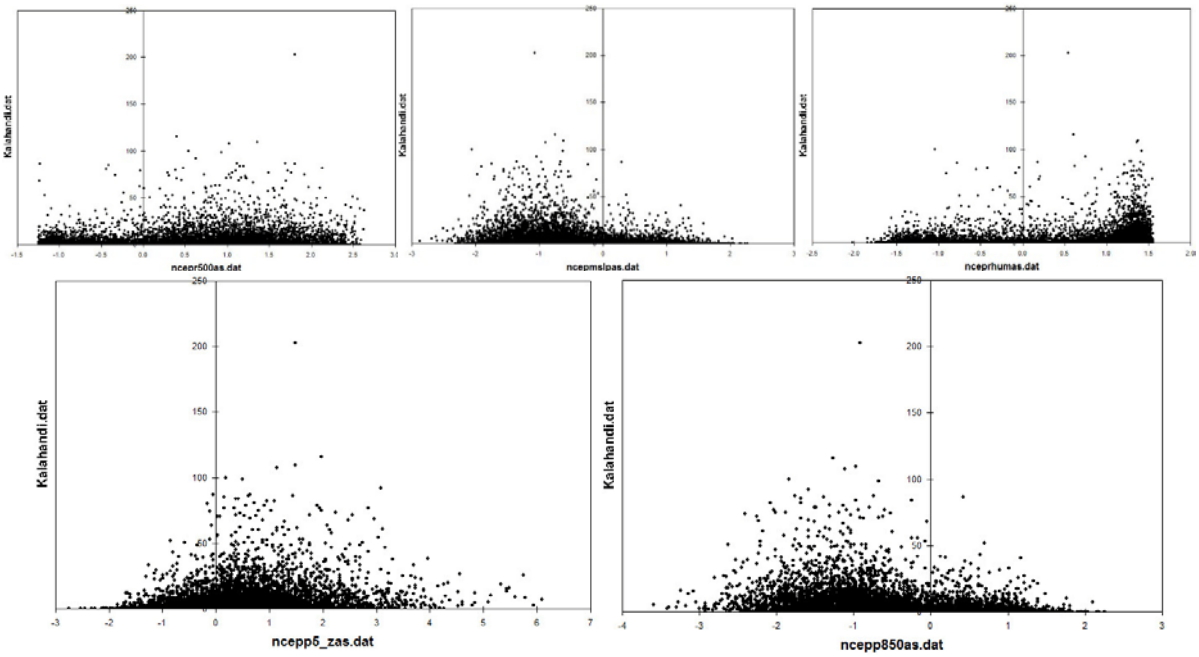
Alreadytrends in long-term climatic data, i.e., rainfall (110 years), temperature (102years), and potential evapotranspiration (102 years) have been investigated on monthly, seasonal and annual series in eight districts spread over in the KBK region in the western part of Odisha, India. The trends are generated using both parametric (linear regression method) and non-parametric (Mann-Kendall test and Sen's Slope estimates). With this the first objective of the study i.e. to analyze long-term historical climatic data to determine trend has been completed. As per the second objective of the study i.e. to analyze the future climate in the region based on downscaled GCM data, future rainfall in the KBK region has been downscaled from HadCM3 A2 and HadCM3 B2 GCM data utilizing SDSM model. The study has been carried out using SDSM tool version 4.2.9.

SDSM is one of the statistical downscaling tools that implement the multiple linear regression model, and provides scenario of daily surface weather variables under the present and future climate forcing. The tool also performs ancillary tasks of data quality control and transformation, prescreening of predictor variables, model calibration and validation, scenario generation, statistical analysis and its representation of climate data.

The observed rainfall data (predictand) for the periods 1971 to 2001 has been used. The daily observed predictor data (re-analysis data)of atmospheric variables, derived from the National Center of Environmental Prediction (NCEP) on 2.5^0 latitude x 2.5^0 longitude grid-scale for 41 years (1961–2001) are obtained from the Canadian Climate Impacts Scenarios (CCIS) website (http://www.cics.uvic.ca/scenarios/sdsm/select.cgi). The large-scale daily predictors of Hadley Center's GCM (HadCM3) for HadCM3 A2 and HadCM3 B2 future scenarios for 139 years (1961–2099)on 3.75^0 latitude x 3.75^0 longitude grid-scale are obtained from the Canadian Climate Impacts Scenarios (CCIS) website (http://www.cics.uvic.ca/scenarios/sdsm/select.cgi). The major steps include in SDSM downscaling are:

(i) Selection of predictors: The appropriate predictor variables are selected through scatter plots, correlation and partial correlation analysis performed between the predictand of interest and predictors.

(ii) Model calibration and validation: Model calibration involves development of an empirical relationship, here multiple linear regression, between the predictand of interest and identified daily observed predictors. Part of the NCEP reanalysis data for the period 1961-1990 is used for model calibration, and remaining data between 1991-2001 for validation.



(iii) Scenario generation: The validated regression model is applied to generate future scenario for the region utilizing the simulated HadCM3 A2 GCMs data. The study assumes that the relationship between predictor and predictand remains valid under the future climate conditions. Twenty ensembles of daily synthetic precipitation for a period of 139 years (1961-2099) have been generated. The ensemble values are averaged and divided into three separate time period viz. 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2099).

Calibration (1961-1990) and validation (1991-2001) result of the model downscaling (1961-1991) of daily rainfall is presented in Table 1.

Table 1: Comparison between Daily Precipitation (Observed) and Daily Precipitation (Computed) during Model Calibration and Validation

Type	Period	Mean	SD	Var	Correlation, r
Model Calibration	Precp_61-91_Observed	3.02	11.70	136.88	**0.51**
	Precp_61-91_Computed	3.59	7.24	52.47	
Model Validation	Precp_92-01_Observed	3.31	14.46	209.01	**0.47**
	Precp_92-01_Computed	3.44	6.69	44.81	

The validated Multiple Linear Regression models between the predictand and large-scale predictors are used to generate the future downscaled data. The annual precipitation corresponding to future emission is presented in Table 2. The result indicates an increase in trend of annual precipitation for successive scenarios. In the 2020s, the simulated annual precipitation is about 200 mm higher than the mean annual precipitation for the present scenario which stands at 1129 mm. Similarly for 2050s and 2080s, the annual mean precipitations are 1515.92 mm and 1692.70 mm respectively. The study indicates an increasing mean daily, monthly and annual precipitation suggesting a wetter climate in the future.

Table 2: Annual average precipitation for present and downscaled precipitation corresponding to HadCM3 A2 and HadCM3 B2 scenario

Scenario	Annual average precipitation (mm)
Present	1129.58
HadCM3 A2 scenario (Worst case scenario with high future emission)	
2020s	1327.17
2050s	1515.92
2080s	1692.70
HadCM3 B2 scenario	
2020s	1277.37
2050s	1457.02
2080s	1503.10

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INTERNAL RESEARCH PROJECT: NIH/WRS/2013/06

1. **Title** - Glacier change and glacier runoff variation in the upper Satluj river basin

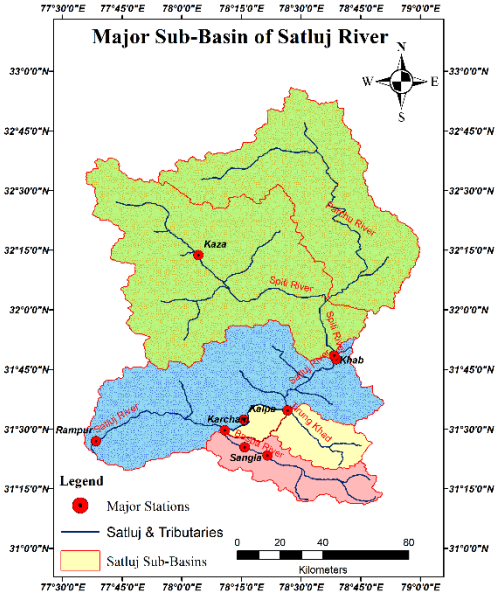
2. **Study Group** - Dr. Sanjay K. Jain, Sc "F"
   Dr.Sharad K. Jain, Sc "G"
   Dr.RenojThayyen, Sc "D"

3. **Date of Start** - October 2013
4. **Schedule date of completion** - March 2016
5. **Type of study** - Internal
6. **Location map/study area**

7. **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.



8. **Statement of the problem:**

Glacier runoff contributions to streamflow provide critical water supply in many mountainous regions. These glacier runoff contributions are highly sensitive to changes in temperature. 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.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 throughout the year is very important.

9. **Action Plan**

1st. Interim report	2nd. Interim report	Final report
April 2014	April 2015	March 2016

10. 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
- Modeling of glacier melt runoff
- Projection of temperature change
- Assessment of changes in glacier melt runoff vis-à-vis glacier change/change in meteorological inputs

11. Achievements:

Three sub basins of Satluj basin are being studied: Baspa, Tirunglhad and Spiti. In these three basins glacier change have been computed using glacier map obtained from Topographical maps (1966) and satellite data (2000, 2006 and 2011). It was observed that the glacier areas in these basins have been receding. An interim report has been prepared in April 2014. Discharge data of three sites (Sangla, Thangi and Khab), temperature data (Raksham, Kaza, Kalpa) as well as snow water equivalent (SWE) have been collected. The data of Raksham and Sangla in Baspa basin have been processed. The processing of the other data is in progress. The progress of the study will be presented in the meeting.

12. Adopters of the results of the study and their feedback

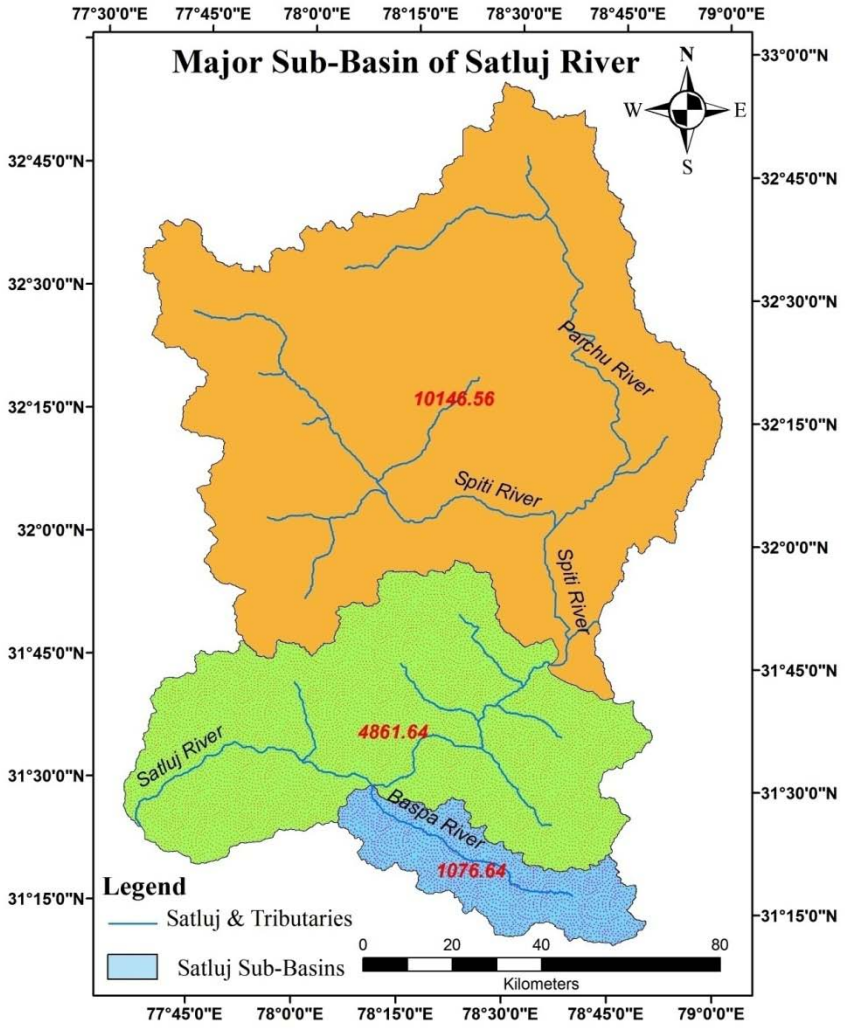
Hydropower Companies and state departments

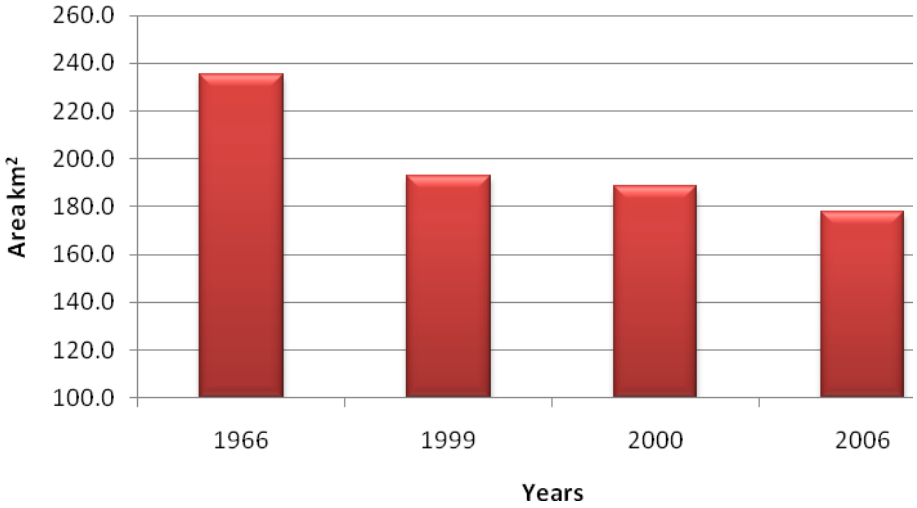
13. Deliverables

The glacier inventory and change in the glacier of the study area. Expected runoff in future and changes in hydropower potential.

14. Data generated in the study

Glacier maps from satellite data.


Major Sub-Basin of Satluj River
N
W
E
S
77°30'0"E
77°45'0"E
78°0'0"E
78°15'0"E
78°30'0"E
78°45'0"E
79°0'0"E
33°0'0"N
32°45'0"N
32°30'0"N
32°15'0"N
32°0'0"N
31°45'0"N
31°30'0"N
31°15'0"N
Parchu River
10146.56
Spiti River
Spiti River
4861.64
Satluj River
Baspa River
1076.64
Legend
Satluj & Tributaries
Satluj Sub-Basins
0
20
40
80
Kilometers


260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
Area km²
1966
1999
2000
2006
Years

INTERNAL RESEARCH PROJECT: NIH/WRS/2013/07

Thrust Area under XII five Year Plan: Sustainable water systems management: Adaptation of hydro-system to climate change

Project Team:

a. **Project Investigator:** Manish Kumar Nema, Scientist 'B'
b. **Project Co-Investigators:** Dr.S. K. Jain, Scientist 'G'/ Head, WRSD

Title of the Project: Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj

Objectives:

a. To collect/procure/computerize long-term hydrological and climatic data of study area
b. To create an integrated hydrological database of lower Satluj
c. To analyze recorded hydro-climatic data for trends or changes in Punjab Plains of lower Satluj
d. To evaluate monthly/seasonal/annual hydrology of the region

Type of Study - Internal

Start Date - November, 2013

Scheduled date of completion - October, 2015

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.

Methodology

Linear Regression and Mann–Kendall Test for Trend Analysis: Prior to perform 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.

Progress Made:

The time series of the monthly rainfall for the nine districts which fall under the study area were analyzed using the Mann-Kendall non-parametric test for trend in the first six months. The magnitude of the trend in a time series was also determined using a non-parametric method known as Sen's slope estimator method. The analysis has also been shown in last working group. In the last six months the both temperature data i.e. minimum and maximum temperature for the said nine districts of Bist-Doab has been processed, analyzed and tested for finding the possible trend and slope of the trend using the same methods used in case of rainfall data.

Annual and three seasonal (i.e. Monsoon, spring and Winter) analysis of both the temperature series i.e. maximum and minimum has been performed. Annual series of maximum temperature are carrying the positive Z-values of Mann-Kendall test statistics but

the trend is rejected at even the significance level of 90%, so no trend in annual maximum temperature series. But, the seasonal analysis showed that winterand the spring temperature are rising over the region as all the district stations are significantly (more than 99%) supporting the increasing trend except Mogadistrict which have a level of 95% in case of spring season. In case of minimum temperature time series, the annual series is supporting rising trend as all the stations having a positive z-values out of nine four with 90% significance level, two station with 95% and one station with 99% significance level. Seasonal analysis of minimum temperature series is bit tricky as winter is following increasing trends of temperature at very significance level (more than 99.9%), whereas, Monsoon or summer season is strongly supporting the decreasing temperature trends (eight station at 99.9% and one station at 99%). Similar to maximum temperature series, the spring season in minimum temperature series also is supporting winter season temperature rising trend at 99% significance level at all stations.

For in-depth analysis we have also divided the entire annual data length of 102 years (1901-2002) in to four periods: period A (1901-1930), period B (1931-1960), period C (1961-1990) and period D (1991-2002) and performed the trend and magnitude analysis for these periods. In case of both the temperature time series period A is showing falling temperature trends with certain significance levels at many of the stations and period B and D are showing rising temperature trends, whereas the period C is not showing any trend. Higher positive z-values and higher significance levels in minimum temperature series in these period are also supporting that for the study period these was rise in the minimum temperature.

The magnitude of the trends in terms of the slope of the linear regression has also been estimated using Sen's slope method. Regionally there is rise in the maximum temperature at the rate of 0.17 ^{0}C/100 years based on annual series. The maximum increase was found in winter series1.17 ^{0}C/100 years at Ludhiana and Moga. And the minimum temperature is rising at the rate of 0.29 ^{0}C/100 yearsover the complete study area with the maximum value of 1.21 ^{0}C/100 yearsat Amritsar and Ludhiana.

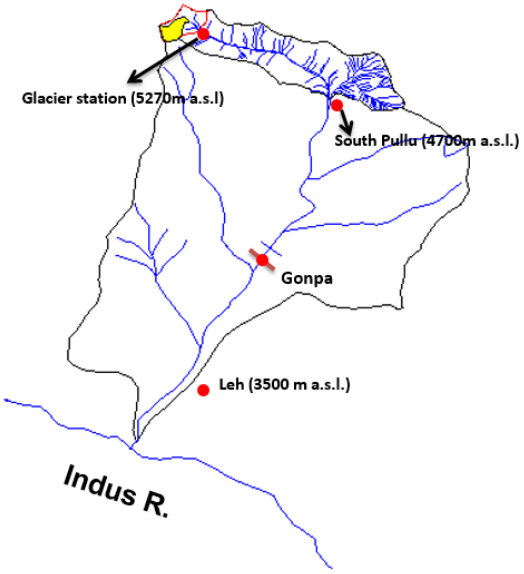
***

INTERNAL RESEARCH PROJECT: NIH/WRS/2013/08

a) Title of the Study **:Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh**

b) **Study Group** : Dr. R.J Thayyen, Dr.S.P Rai, ,Dr**.** Sanjay Jain, Dr.Sudhir Kumar

c) **Date of Start** : July 2014
d) **Schedule date of completion**: July 2017
e) **Type of study** : NIH
f) **Location map / Study area** :



Objectives of the study are:

1. To improve the understanding of the climate forcing on cold-arid cryospheric system and Hydrology.
2. To improve the understanding of the melt water generation process and the role of permafrost.
3. To study the temporal variations in isotopic characteristics of winter base flow and summer flow of the perennial reach and its cryospheric linkages.

a) Statement of the problem:

The proposed project is the second phase of the project entitled “Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range”. The project under phase-1 has revealed many unknown facets of the hydrology of the cold-arid cryospheric system such as catchment specific runoff of nival/glacier system, very high temperature lapse rate under cold-arid climate, Low contribution of glacier melt and significant contribution from frozen ground etc. While the earlier project has concentrated on the high altitude Nival/glacier system with catchment outlet at 4700 m a.s.l., the present project has aimed to expand the research preview to the foothill zones to achieve a more comphrehensive understanding of the cold-arid system hydrological processes with a view to assist people in managing these scarce resources.

i) Approved action plan

ii) Monitoring of weather parameters by AWS at 3500 m a.s.l., 4700 m a.s.l. and 5600 m a.s.l. for studying the orographic forcing
iii) Monitoring discharge and Electrical conductivity at 4700 m a.s.l& 3500 m a.s.l.
iv) Measuring ground temperature for permafrost studies
v) Geophysical investigation of potential permafrost zones
vi) Isotope studies of stream discharge at 4700m a.s.l. and 3500 m a.s.l.
vii) Runoff modeling by SNOWMOD by incorporating the new SELR concept.

j) Achievements

Year	Objectives (for the period June 14 – Ocotber 2014)	Achievements
2013	i. Catchment runoff measurements ii. Year round monitoring of meteorological parameters iii. Catchment runoff modeling iv. Stable isotope measurement of stream flow **v.** Hydrograph separation by isotope method	New station established, 3650 m a.s.l. New station established at 3700 m a.s.l Progressing Pending

k) Recommendation / suggestions in previous meetings of Working group / TAC / GB

There were no specific/major recommendations pertaining to the study.

l) Progress

This is a new study initiated in July 2014 in continuation of the studies of last 05 years in the Ladakh region. In view of the expanded research preview, a new discharge and meteorological station are established at 3700 m a.s.l. at Gonpa area. This discharge station at the perennial stretch of the interrupted stream is established with a view to gather hydrological information throughout the water year,which may provide some insight on surface water – ground water interaction and information of possible permafrost degradation/seasonally frozen ground in the catchment. Discharge measurement at 4700m a.s.l. continued during the reporting period.

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

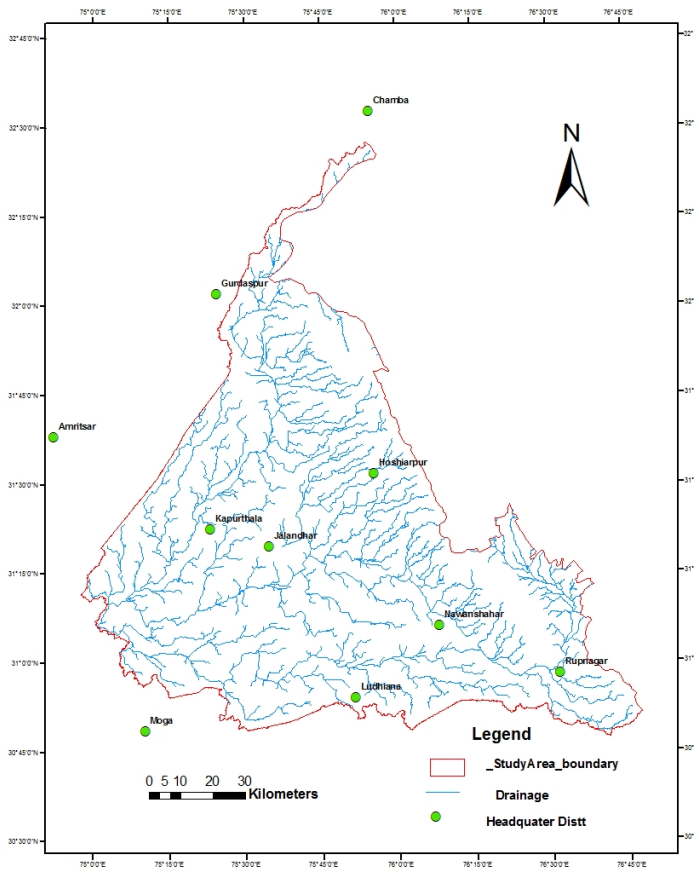
Catchment runoff data at 4700 m asl.-01 Years. &Isoptopic data of stream flow at 4700 m asl.

INTERNAL RESEARCH PROJECT: **NIH/WRS/2013/09**

1. **Thrust Area under XII five year Plan:** Integrated water resources management/ watershed hydrology
2. **Project Team:**
   a. **Project Investigator:** P. K. Agarwal, Scientist "B"
   b. **Project Co-Investigators**: Shri Tanvear Ahmed, Scientist "B"
   Dr Sanjay K. Jain, Scientist 'F"
   Dr. M. K. Goel, Scientist "F"
   Dr. Sharad K. Jain, Scientist "G"
   Shri Manish Nema, Scientist "B"
3. **Title of The Project** Hydrological modeling of a part of Satluj basin using SWAT Model
4. **Date of Start -** July 2014
5. **Schedule date of completion** March 2017
6. **Type of study -** Internal
7. **Objectives:**
   - To develop the data base of a part of Satluj river basin (between Ropar D/s of Bhakra dam to Harike) and
   - To Carry out Hydrological modeling of the basin using ArcSWAT model to find out water balance components e.g. Actual evapo-transpiration etc.
8. **Approved Action Plan**

S N	Work element	**First year 2014-15**	Second year 2015-16	Third year 2016-16
	Deliverable	• **Literature Review** • **Data collection** • **Preparation of data base for SWAT**	• Preparation of data base for SWAT • Application of SWAT • Analysis of results	• Analysis of results • Preparation of Report
		1st. Interim report	2nd. Interim report	Final report
		April 2015	April 2016	March 2017

9. **Study Area Selected:** Satluj river basin (between Ropar D/s of Bhakra dam to Harike) as given in figure.



Map of Study Area

10. Methodology

In the present study, the following methodology is being adopted:

- Data base preparation in ArcGIS (DEM, Land use, soil map)
- Collection of metrological data (rainfall, temperature, wind, solar radiation, humidity)
- Setup of SWAT model using Arc-GIS.
- Calibration and validation of SWAT model
- To carry out the effect of land use & other changes on stream flow.

11. Progress Made between July 2014 – October 2014

- Basin and drainage map has been selected;
- DEM map has been downloaded;
- Preparation of Land use & Soil maps are in the final stage of completion;
- Literature review in progress;
- As per the recommendation of the previous working group, Shri Manish Nema has been included in the study group. The Meteorological data has been collected by Shri Nema, which will be used in the study.

*****

INTERNAL RESEARCH PROJECT: NIH/WRS/2013/10

Thrust area under XII five year plan: Integrated Water Resources Development & Management

Project team:

a) **Project Investigator:** D.S. Rathore, Sc."F"
b) **Project Co- investigators:** M. K. Goel, Sc."F",
R.P. Pandey, Sc."F",
Sanjay Kumar, Sc."D",
Surjeet Singh, Sc."D"

Title of Project - Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra

Objectives:

a) Rainfall- runoff modeling and estimation of water availability in the basin
b) Multi-reservoir operation in the basin for project complexes
c) Drought prediction
d) Water quality modeling in the basin
e) Conjunctive use operation in command area
f) Rainfall- runoff modeling and river basin simulation for climatic change scenarios

Statement of Problem

A Decision Support System (Planning) has been developed under Hydrology Project - II for State and Central implementing agencies. Pilot study was carried out for Upper Bhima basin. Further development of applications and interfaces, porting of models to Mike Hydro is proposed in the study.

Location map/ study area

Upper Bhima basin up to Ujjani in Maharashtra state.

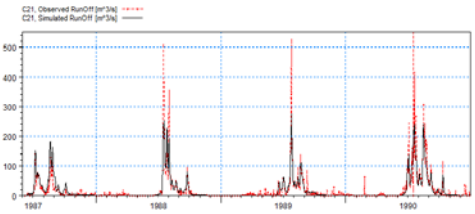
Approved action plan and time line

S. No.	Work Element	2014-15			2015-16			
		II	III	IV	I	II	III	IV
1	Data collection							
2	Rainfall- runoff modeling							
3	River basin modeling							
4	Drought indices							
5	conjunctive use							
6	River water quality modeling							
7	Interfaces for decision support							
8	Climatic change scenarios							
9	First Interim Report							
10	Final Report							

Recommendations / suggestions in previous WG

None

Achievements

Year	Objectives	Achievements
2014	Rainfall- runoff modeling and estimation of water availability in the basin	NAM model was developed and calibrated for 24 catchments (14 headwater and 10 intermediate catchments).  Fig. Observed and simulated inflow to Warasgaon
2014	Multi-reservoir operation in the basin for project complexes	Mike Hydro setup and simulated for Khadakwasla complex for normal hydrological conditions.
2014	Drought prediction	SPI and EDI were computed using monthly rainfall data.
2014	Water quality modeling in the basin	Water quality model was set up and simulated for Mula- Mutha- Bhima river system.
2014	Conjunctive use operation in command area	Conjunctive model was setup for Khadakwasla canal command area and simulation was done for different water supply scenarios in distributaries.

Data procured and generated during the study:

Time series of extended discharge, drought indices were generated.

EXTERNAL RESEARCH PROJECT: NIH/WRS/2010/01

a) **Title of the Study** : ***Glaciological studies of Phuche Glacier, Ladakh Range***.

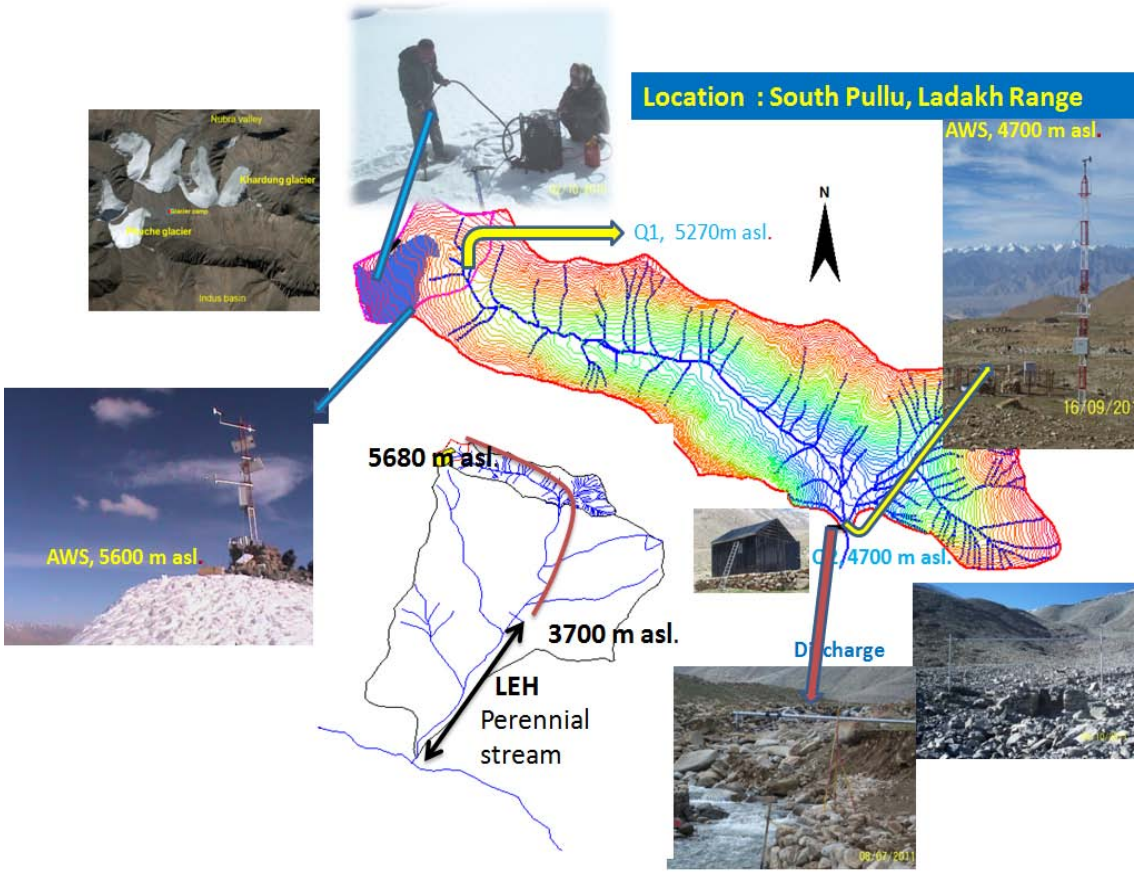
b) **Study Group** : Dr. R.J Thayyen, Dr.S.P Rai & Dr. M.K Goel

c) **Date of Start** : 1st January 2010

d) **Schedule date of completion**: December 2014

e) **Type of study** : Sponsored Project (DST, Rs. 54.6 Lakhs)

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.

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	b) Yearly winter and summer mass balance measurement	Achieved
	c) Glacier runoff measurements	Achieved
	d) Year round monitoring of meteorological parameters and standardization	Achieved
	e) Mass balance & runoff modeling	Under progress
	f) Stable isotope characterization of winter snow pack, summer rain/snow and stream flow	Achieved/under progress Achieved/under progress
	g) Hydrograph separation by isotope method	Under progress
	h) 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) Progress:

Glacier response to prevailing weather is influenced by many factors like regional/local climate, aspect, altitude, Debris cover, dust/soot deposits etc. How to achieve a region specific understanding of glacier response – climate relationship by resolving these various forcing factors is a challenging question. Glacier melt contribution to the catchment runoff across the Himalaya under various glacio-hydrological regimes are also not well understood.

This knowledge gap is primarily because of the standard practice in India to estimate only the annual glacier mass balance leaving aside the melting snow accumulated in winter and summer precipitation contributions. Under this project, winter and summer mass balance of Phuche and Khardung glaciers were studied. These two glaciers are part of Khardung glacier complex in the cold-arid climate and situated just 2.5 Km apart on the Ladakh Range near Leh. These glaciers are being monitored for winter and summer mass balance since 2010 by glaciological method. Both these glaciers have same NE aspect but have different wind regime as the Khardung glacier is situated on the northern slopes of the Ladakh range feeding to the Nubra valley and the Phuche glacier is in the Ganglass valley feeding to the River Indus. During the four years of study (2010-2013), Phuche glacier experienced two slightly positive mass balance years interspersed with two significant negative mass balance years. While Khadung glacier experienced consistent mass loss with a remarkable cumulative mass loss of (-)2690 mm w.e. during these four years. Cumulative mass loss of Phuche glacier was significantly less at (-)670 mm w.e. during the same period. Winter mass balance of Phuche glacier ranged between 660 to 590mm w.e and annual mass exchange from the glacier range between 630 to 835mm w.e. Winter mass balance of Khardung glacier range between 690 to 567mm w.e and annual mass exchange from Khardung glacier ranged between 1140 to 770mm w.e. These values gives the first information on mass exchange on a Himalayan glacier and suggest that the winter snow accumulation on the glacier is many fold than the precipitation monitored at the valley bottom at Leh at 3500m a.s.l. Lack of precipitation data from glacier accumulation area is proved to be one of the key factors restraining our understanding on the glacier contribution to the stream flow and catchment/basin water balance. This study provide a firm basis for a reliable water balance estimate of the headwater catchments of the cold-arid system. This study also provided the first unequivocal evidence of mass loss of Ladakh glaciers in response to prevailing weather and suggests that the southern extent of the 'Karakorum anomaly' did not reach the Ladakh range.

During the reporting period summer mass balance measurements were continued in the Phuche and Khardung glaciers. The weather parameters were monitored and the weather data is analysed to study the seasonal variations of meteorological variables and resultant glacier melt. Modelling of glacier melt is attempted through the degree-day approach and energy balance components were prepared modelling.

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. and Electrical conductivity data of stream discharge.

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EXTERNAL RESEARCH PROJECT: NIH-E/WRS/2014/02

Project Team:

a. **Project Investigator:** Dr.S. K. Jain, Scientist 'G'/ Head, WRSD
b. **Project Co-Investigators:** Dr. Pradeep Kumar, Scientist 'B', WHRC
Shri P. K. Agarwal, Scientist 'B'
Shri P. K. Mishra, Scientist 'B'

Title of the Project: Assessment of Environmental flow for Himalayan River

Type of Study	-	MOES Sponsored
Amount	-	8.61 Lakhs
Start Date	-	Nov., 2014
Scheduled date of completion	-	Nov, 2015

Status:

A project proposal for carrying out work to create baseline database and estimate environmental flows for a few Himalayan rivers was submitted to the Ministry of Earth Sciences and the same has been approved. Formal orders have been issued and funds have been received recently.

Work has started to collect the data and create the database.

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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	Dr (Mrs) Jyoti Patil	Scientist B (LCU)
4	Sri Subhash Kichlu	PRA
5	Sri Rajesh Agarwal	SRA

WORK PROGRAMME FOR YEAR 2014-2015

SN	Title of Project/Study, Study Team	Duration
1.	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs (**Joint Study)** **NIH HQs:** V C Goyal (Leader), Omkar Singh, R V Kale **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu, RC-Kakinada, RC-Sagar, CFMS-Guwahati, CFMS-Patna	DOS: Apr 2012 DOC: Mar 2015
2.	Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, J.V. Tyagi and Sanjay K. Jain	DOS: Apr 2013 DOC: March 2015
3.	Participatory development of structure for IWRM Framework in identified sub-basins under Pilot Basin Studies (PBS) program **Team:** V C Goyal (PI), Omkar Singh and R V Kale	DOS: July 2014 DOC: June 2015
4.	Customization of WEAP model for application in Ur river watershed in Tikamgarh district of Bundelkhand region. **(Under TIFAC Project)** **Team:** R V Kale (PI), T Thomas- RC Bhopal, Jyoti Patil, Rajesh Agarwal	DOS: Apr 2014 DOC: Sep 2015

Sponsored Projects

3. Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India, **Funded by TIFAC, Government of India under INDIA-IIASA Programme of TIFAC**
   Period: Aug 2013-Dec 2016 (30 months) Budget: Rs 56.64 lakh
   Team from NIH:
   V C Goyal (PI), T Thomas (Co-PI), R V Kale (Co-PI)
   Nodal Coordinators from other partners:
   Dr (Mrs) K Vijaya Lakshmi, DA, New Delhi
   Dr Sandeep Goyal, MAPCOST, Govt. of MP (India)
   International Collaborators: IIASA, Austria

4. Development of a DSS for Hydrology and Watershed Management in Neeranchal Project, **To be funded by Dept. of Land Resources (GoI) under a World Bank supported project**
   Period: Jun/Jul 2014-May 2019 Budget: Rs 30 Crore approx.
   Partners: NIH; IIT Delhi; WTC Delhi; NRSC Hyderabad

Study - 1

1. **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.

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.

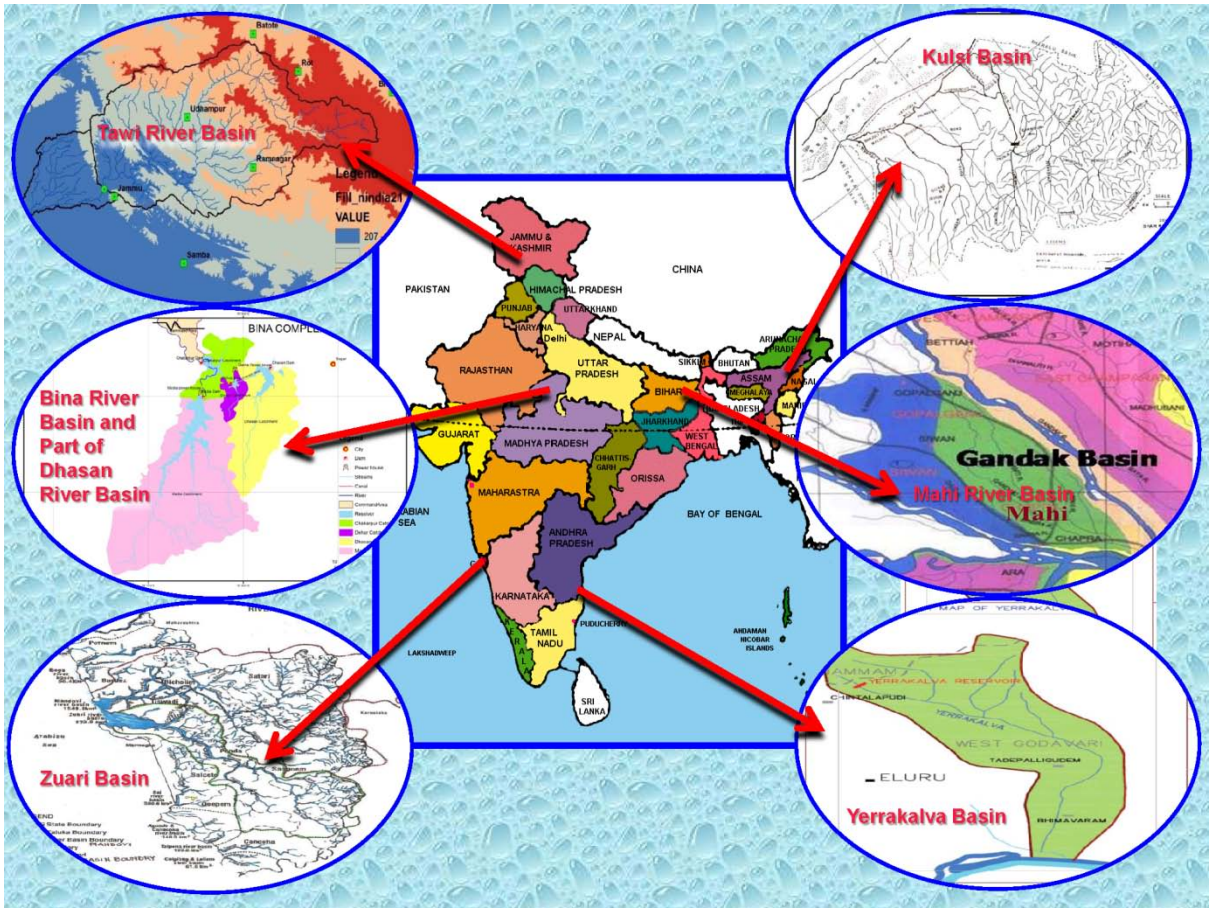


Figure 1. Pilot basins selected under IWRM-PBS program of NIH by its different RC/CFMS.

Achievements:

Studies and Activities under IWRM-PBS Program undertaken at different RCs and Scientific Divisions at the HQs are given below:

S N	Study & Team	Period	Output/Deliverable
	HQs		
1.	Pilot Basin Studies (PBS) at six sites (RMO Division) V C Goyal and R V Kale	2012-2015	1. Consultation meet at Roorkee (2 Apr 2012) 2. IWRM-PBS flyer (Mar 2013) 3. Brainstorming session at Delhi (21-22 Mar 2013) 4. Paper in IWRM-2014 conf at CWRDM (Feb 2014) 5. Inception report (Apr 2014)
2.	Hydrological Instrumentation and Data Monitoring Planning for Integrated Water Resources Management (IWRM) of the Bina River Pilot Basin (GWH Division) Surjeet Singh, N.C. Ghosh and R.K.	2012-2015	

	Jaiswal (RC-Sagar)		
3.	Participatory development of structure for IWRM Framework in identified sub-basins under Pilot Basin Studies (PBS) program (RMO Division) V C Goyal, Omkar Singh and R V Kale	2014-2015	
4.	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P. (SWH Division) J.V.Tyagi and YRS Rao (RC-Kakinada)	2014-2015	
	RC-Jammu		
5.	Integrated Hydrological Study of Tawi Basin P. Kumar, M. K. Nema, and R. J. Thayyen	5 yrs w.e.f. 2012-13	1. Brainstorming session at Jammu (16 Apr 2013) 2. Brief status report (Feb 2013)
	RC-Bhopal		
6.	IWRM in Bina River Basin in Bundelkhand Region in Madhya Pradesh T. R. Nayak, T. Thomas, Ravi Galkate and R.K. Jaiswal	2012-2015	1. Brainstorming session at Bhopal (29 Nov 2012) 2. Status report (Apr 2013) 3. Workshop at Bina (27 Sep 2013)
7.	Surface and ground water modeling for conjunctive use T. R. Nayak, T. Thomas, Ravi Galkate and R.K. Jaiswal	2014-2015	
	RC-Kakinada		
8.	Integrated Water Resources Management in Yerrkalva Basin, Andhra Pradesh – Part I (Status Report) Y.R. Satyaji Rao and S.V. Vijaya Kumar	May 2012 - Dec 2013	1. Brainstorming session at Eluru (31 Aug 2012) 2. Status report (Nov 2012)
9.	IWRM studies in the Yerrakalva River Basin, Andhra Pradesh (PART-II) Y.R. Satyaji Rao and S.V. Vijaya Kumar	2013-2017	
10.	Surface water and Ground water interaction study in the Y drain of lower Yerrakalva basin as part of pilot basin studies for IWRM S.V.Vijayakumar, Y.R.Satyaji Rao, R.Venkata Ramana, and B. Krishna	2014-2015	
11.	Water availability: IWRM studies in the Yerrakalva River Basin, Andhra Pradesh Y.R. Satyaji Rao and B.V.Ramana	2014-2015	
	RC-Belgaum		
12.	Integrated Water Resources Management (IWRM) on a Pilot Basin-Zuari River Basin, Goa Chandramohan T, B K Purendra, and V C Goyal	2013-2016	1. Brainstorming session at Goa (27 Nov 2012) 2. Status report (Feb 2013) 3. Trg Workshop on Project Hydrology (20-22 Nov 2013)
	CFMS- Patna		
13.	Pilot Basin Studies (PBS) for Mahi River Basin in Ghaghra-Gandak Composite Basin	2012-2017	1. Brainstorming session at Patna (21 Dec 2012) 2. Status report (Feb 2013)

14.	Time Series analysis of Monthly Rainfall in Mahi Basin NG Pandey, B Chakravorty, and SR Kumar	2014-2016	
	CFMS- Guwahati		
15.	Assessment of Ground Water Quality in Kulsi River Basin C. K. Jain, S. K. Sharma and P. K. Sarkar	2012-2013	
16.	Status Report on Kulsi River Basin S. K. Sharma	2012-2013	
17.	Application of Arc-SWAT Model for Prediction of Runoff Within Pilot Basin (PBS)	2013-2014	
18.	Short Term Flood Forecasting Using Bootstrap based Artificial Neural Networks within Pilot Basin (PBS)	2013-2014	
19.	Risk Assessment of Heavy Metal Pollution in Surface Soils of Kulsi River Basin (Assam / Meghalaya) C. K. Jain, S. K. Sharma, G. Tirkey and B. Sharma	2013-2015	
20.	Estimation of Runoff for Kulsi River Basin using SCS Curve Number and Geographic Information System (GIS) S. K. Sharma, G. Tirkey and C. K. Jain	2014-2016	
21.	Application of USLE model for estimation of soil loss in Kulsi River Basin using remote sensing and geographic information system G. Tirkey, S. K. Sharma and C. K. Jain	2014-2016	

Study - 2

1. **Title of the Study:** WATER CONSERVATION AND MANAGEMENT IN IBRAHIMPUR MASAHI VILLAGE OF HARIDWAR DISTRICT (UTTARAKHAND)

2. **Study Group:**

Principal Investigators
Omkar Singh, V.C. Goyal, C.K. Jain, J.V. Tyagi and Sanjay K. Jain
Scientific/Technical Staff
Subhash Kichlu, Yatveer Singh, Rajesh Agarwal, Rakesh Goyal, N.K. Lakhera and C.S. Chowhan

3. Type of Study: Internal

4. Date of Start: April, 2013

5. Scheduled Date of Completion March, 2015

6. Duration of the Study: 2 years

7. Study Objectives:

- Assessment of water demand in Ibrahimpur Masahi Revenue Village of the Haridwar District
- Assessment of water availability in Ibrahimpur Masahi Revenue Village of the Haridwar District
- Assessment of water quality status/Eutrophication of Ponds in Ibrahimpur Masahi Revenue Village of the Haridwar District
- Preparation of water conservation plan for the identified village (s)
- Mass awareness activity for participatory water conservation & management

8. 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.

The present study has been taken for Ibrahimpur Masahi revenue village, lying under Shipla Nadi-Halzora Nadi watershed (a tributary of Solani River), District Haridwar (Uttarakhand). The Shipla Nadi-Halzora Nadi watershed lies from 29^0 55' to 30^0 05' North latitude and 77^0 50' to 77^0 55' East longitude under SOI Toposheet Nos. 53 F/16 and 53 G/13 (1:50,000).

The area of Ibrahimpur Masahi revenue village is 14.26 km^2. The Ibrahimpur Masahi revenue village consists of 5 five sub-villages under its jurisdiction, namely- Ibrahimpur, Masahi, Belki, Inayatpur and Halzora.

9. Methodology: In this study, the necessary data from different sources was obtained for human population, cattle and crop acreage and types in the area. Field investigations were carried out to study soil characteristics (Infiltration, Soil texture and soil moisture, etc.) under different land uses. The surface and ground water quality monitoring and analysis was carried out as per standard procedures (APHA 1989; Jain and Bhatia, 1987). The water quality will be evaluated for drinking (BIS-2012) and agriculture purposes (BIS-1987/2001; USDA 1954). Eutrophication of ponds will be assessed using Carlson's Trophic State Index (Carlson, 1977) and to suggest rejuvenation of the ponds. Rainfall data for 27 years (1987 to 2013) was used to decipher dependable rainfall at 50% and 75% frequency levels based on data of nearest hydro-meteorological observatory at Roorkee. The main water harvesting potential structures to be identified in the study area include: existing ponds, roof top water harvesting structures (school & Govt. building), check dams, etc. 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. The brief methodology is given below:

Estimation of Domestic Water Requirement (Human Needs): In this study, the quantity of domestic water (m^3) per capita per day (DWR_d), per month (DWR_m), and per annum (DWR_a) was estimated as follows:

$$DWR_d\ (m^3/day) = (P_{rural} \times 40 + P_{urban} \times 135)\ x10^{-3}$$

$$DWR_m(m^3/month) = (P_{rural} \times 40 + P_{urban} \times 135)x10^{-3} \times 30$$

$$DWR_a(m^3/annum) = (P_{rural} \times 40 + P_{urban} \times 135)x10^{-3} \times 365$$

Livestock Water Requirement: Livestock Water requirement (LWR) refers to the quantity of water required for drinking and animal hygiene conditions (animal and place washing). The water required for livestock rearing depends on the number of animals and consumptive use per head (Amarasinghe *et al.*, 2004). The total livestock water requirement daily (LWR_d, m^3/day), monthly (LWR_m, m^3/month) and annually (LWR_a, m^3/annum) were estimated by adding water required for all domestic animals such as- cattle (cow family), buffaloes, bovines (cow family)/yak, sheep, goat, swine, and poultry (Frasier and Hyers, 1983):

$$LWR_d\ (m^3/day) = \{C \times 85 + B \times 85 + B_o \times 85 + S \times 10 + G \times 10 + S_W \times 15 + P \times 0.40\}\ x10^{-3}$$

$$LWR_m\ (m^3/month) = \{C \times 85 + B \times 85 + B_o \times 85 + S \times 10 + G \times 10 + S_W \times 15 + P \times 0.40\} \times 10^{-3} \times 30$$

$$LWR_a\ (m^3/yr) = \{C \times 85 + B \times 85 + B_o \times 85 + S \times 10 + G \times 10 + S_W \times 15 + P \times 0.40\} \times 10^{-3} \times 365$$

Where, C is number of Cattles, B is number Buffaloes, B_o is number of Bovines/yalk, S is number of Sheep, G is number of Goats, S_W is number of Swines, P is number birds (poultry).

Crop Water Requirement: Crop water requirement was estimated broadly using Inductive method based on standard crop deltas (Varshney, et. al, 1983; Garg, 2005). Accordingly, the quantity of water requirements (IWR, m^3) is the product of cropped area (CA, m^2) and standard delta (Δ, m) of respective crops during different seasons as given below:

$$CWR\ (m^3) = CA\ (m^2) \times \Delta\ (m)$$

Typical values of standard deltas (S_Δ) are adopted from Table (Varshney, et. al, 1983).

Probability Analysis of Rainfall Data

The analysis of rainfall trend for the study area was carried out using 27 years monthly rainfall data pertaining to Hydro-meteorological Observatory of NIH Roorkee. The monthly data was arranged in descending order of their magnitude. The recurrence interval T (return period) of a particular magnitude was determined using Kimball's method (Weibull, 1939) as below:

$$T = (n+1)/m$$

Where, T= recurrence interval (return period), n= total number of items data series, m= order number or rank of any particular storm value after arranging in descending order of their magnitude. The frequency F (expressed as percent of time) of that storm magnitude (having recurrence interval, T) is given by:

$$F\ (\%) = (1/T)100$$

In the present study, frequency curve (Precipitation P or I v/s F%) were developed for monthly rainfall data of the Roorkee using 27 years rainfall data.

Estimation of surface runoff

Estimation of surface runoff is essential for the assessment of water yield potential of a watershed, planning of soil and water conservation measures, reducing the sedimentation and flooding hazards downstream. The Soil Conservation Service Curve Number (SCS-N) method, developed by the USDA-Soil Conservation Service (SCS, 1972), is widely used for the estimation of direct runoff for a given rainfall event from small agricultural watersheds. The mathematical form of SCS-N method is given below:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

Where, Q= direct surface runoff in depth (mm)

P= Storm rainfall (mm)

S= maximum potential difference between rainfall and runoff (mm)

For convenience in evaluating antecedent moisture, soil condition, land use, and conservation practices, the U.S. Soil Conservation Service (1972) defines

$$S = \frac{25400}{N} - 254$$

Where, N= an arbitrary curve number varying from 0 to 100. The curve number (N) can be obtained for various hydrologic soil group (A, B, C, D) on the basis of landuse/land cover, treatment/practice and hydrologic condition (good/poor/fair) as depicted under USDA-Soil Conservation Service (SCS, 1972).

Estimation of Evapotranspiration (ET, mm/day)

The ET will be estimated using CROPWAT8 (Penman-Monteith Method)/Hargreaves Temperature Model on the basis of available data. The input data requirement for

CROPWAT8 includes: monthly minimum temperature (^{0}C), maximum temperature (^{0}C), humidity (%), wind (km/day), sun shine hrs (hour). The Hargreaves Temperature Model is expressed as below:

$$ET0 = 0.0023Ra\,(Tmean + 17.8)\sqrt{(Tmax - Tmin)}$$

Where ET_0= Evapotranspiration (mm/day), Tmean, Tmax and Tmin= mean, maximum and minimum air temperatures (^{0}C), respectively. Ra= extraterrestrial radiation (mm/day).

10. 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/Collection of necessary data for the study								
4.	Field investigations (WQ, WL Monitoring, survey of ponds etc.) and inventory of village water resources								
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 (s) preparation								

11. Objectives and achievement during last six months:

Objectives	Achievements
i) Assessment of water demand in Ibrahimpur Masahi Revenue Village of the Haridwar District.	• Estimation of Water Demand for Domestic, Livestock and Agriculture has been completed based on data obtained from various sources. (June, 14).
ii) Assessment of water availability in Ibrahimpur Masahi Revenue Village of the Haridwar District.	• Frequency analysis of monthly rainfall data pertaining to Roorkee for 27 Years (1987-2013) was carried out and deciphered dependable rainfall at F=50% and F=75%, respectively. Accordingly, Rain Water Availability at village and watershed level was carried out. (June, 14).
	• Drainage pattern was prepared using DEM and landuse map is under progress. • Measurement of cross section, water level and velocity data (Sept., 2014) of Shipla-Halzora Nadi was monitored at Imlikhera. The data was analysed to estimate the discharge of the river for Sept., 2014. • The soil texture and soil moisture data was analysed for the study area. • Necessary data (Latitude, Longitude, Perimeter, Area) pertaining to village ponds under Ibrahimpur Masahi Revenue village was deciphered from the maps for capacity estimation of the ponds.
iii) Assessment of Water Quality Status/Eutrophication of Ponds in Ibrahimpur Masahi Revenue Village of the Haridwar District.	• Water quality sampling from River, Ponds, Hand Pumps/Tubewells, etc. was carried out in the study area and data was analyzed.
iv) Preparation of water conservation plan for the identified village (s)	• Preliminary Investigation of existing ponds was carried out and capacity estimation is in progress • Identification of potential water harvesting structures (Ponds, roof top water harvesting structures viz. schools/Govt. buildings/Panchayats, sites for check dams, etc.) is in progress
v) Mass awareness activity for participatory water conservation & management	• To be conducted in the 3rd/4th quarter in village.

12. Recommendation / Suggestion:

Recommendation / Suggestion/Queries	Action Taken
-	-

13. Analysis & Results: The water demand for domestic, livestock and agricultural uses has already been estimated for the Ibrahimpur Masahi Revenue Village. During the reporting period, the water quality monitoring & analysis of different sources, delineation of drainage pattern, soil moisture and textural analysis and measurement of discharge of

Shipla-Haljora nadi was carried out for the period of 28.8.2014 to 30.9.2014. The key results are given below:

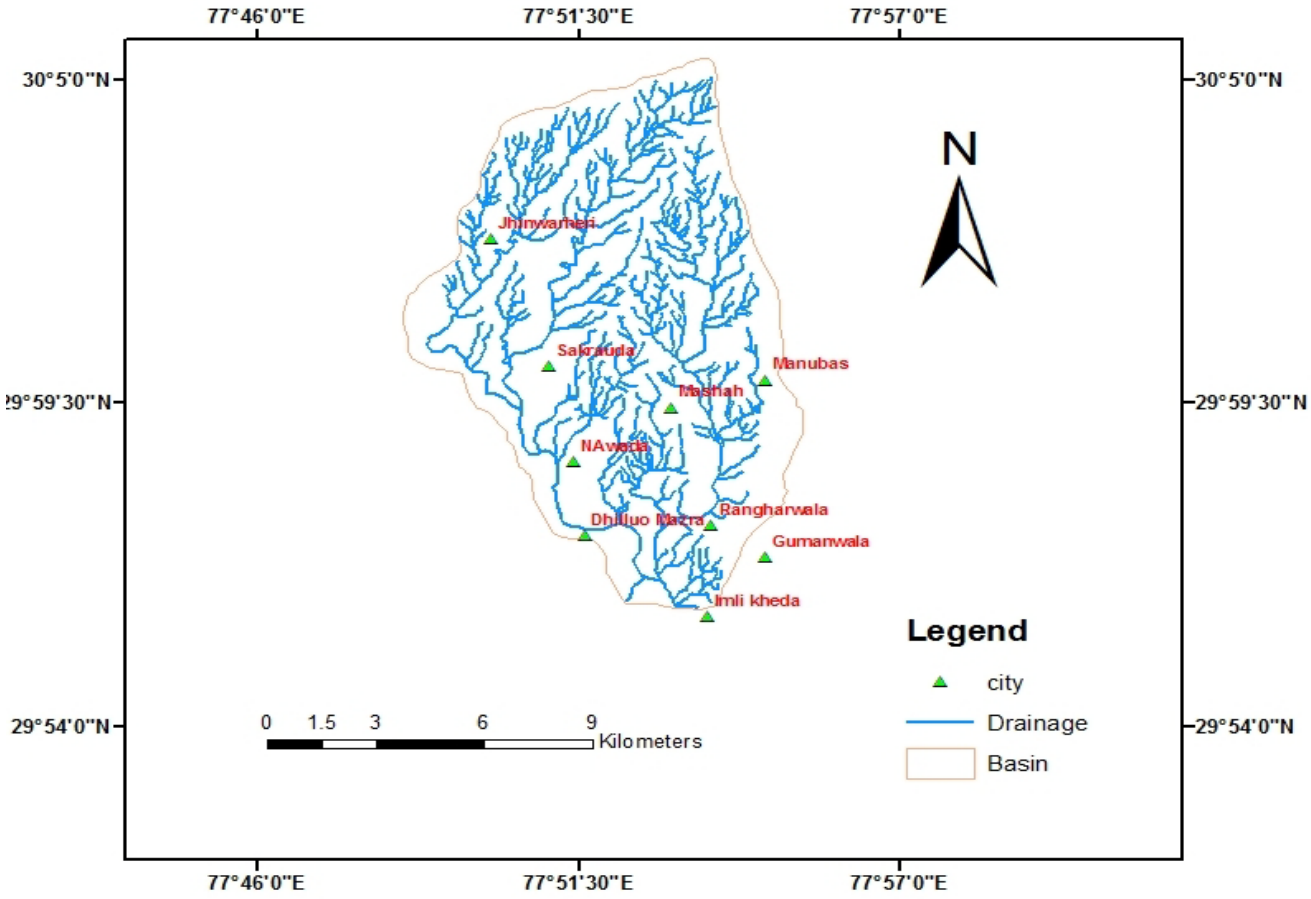


Fig. Drainage Pattern of the Shipla-Haljora Nadi Watershed upto Imlikhera

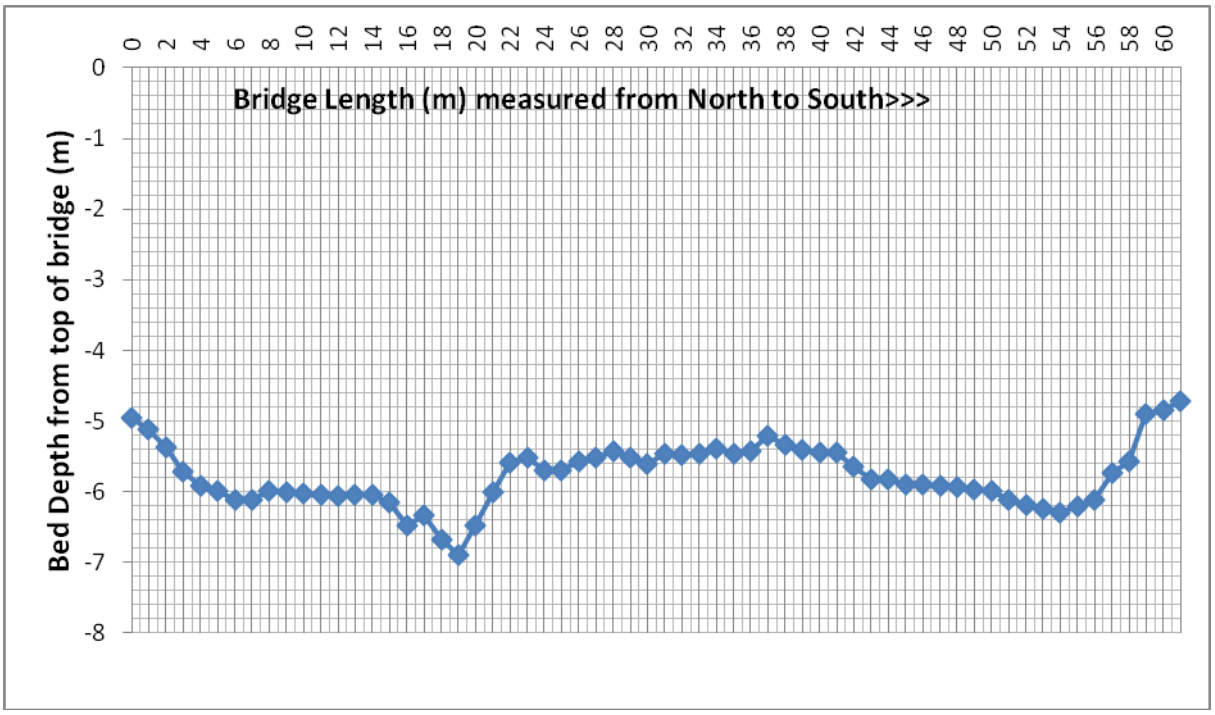


Fig. : Cross Section of Shipla-Haljora Nadi Near Imlikhera, Dist. Haridwar

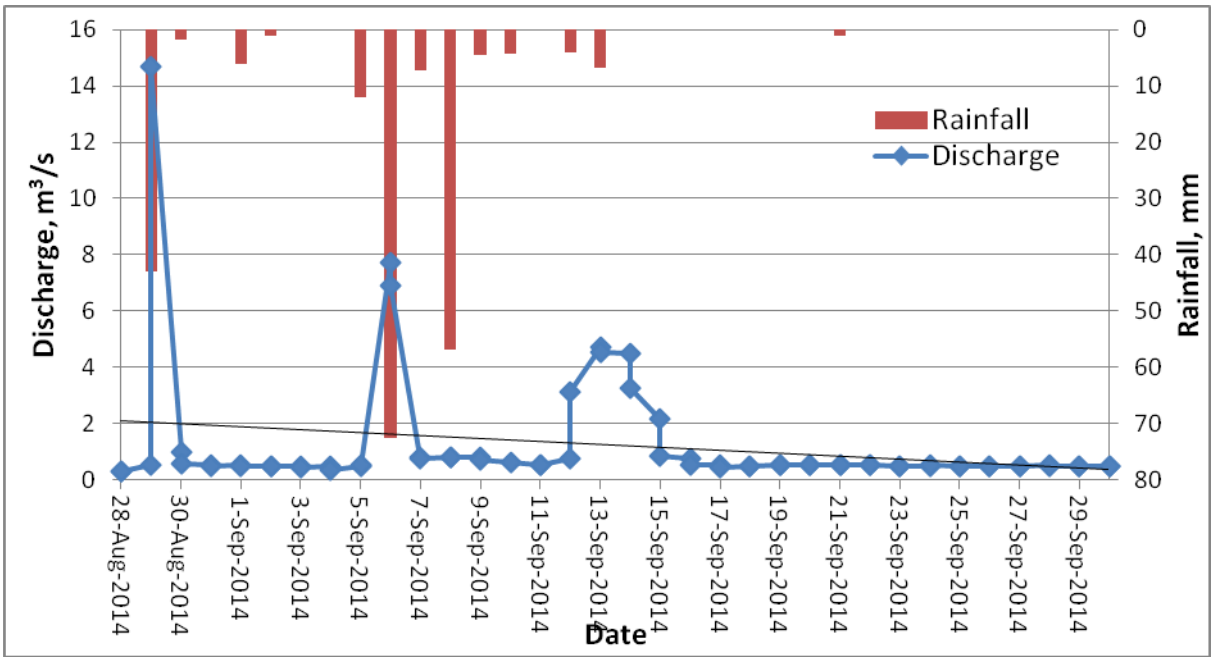


Fig. : Discharge of Shipla-Haljora Nadi Near Imlikhera, Dist. Haridwar

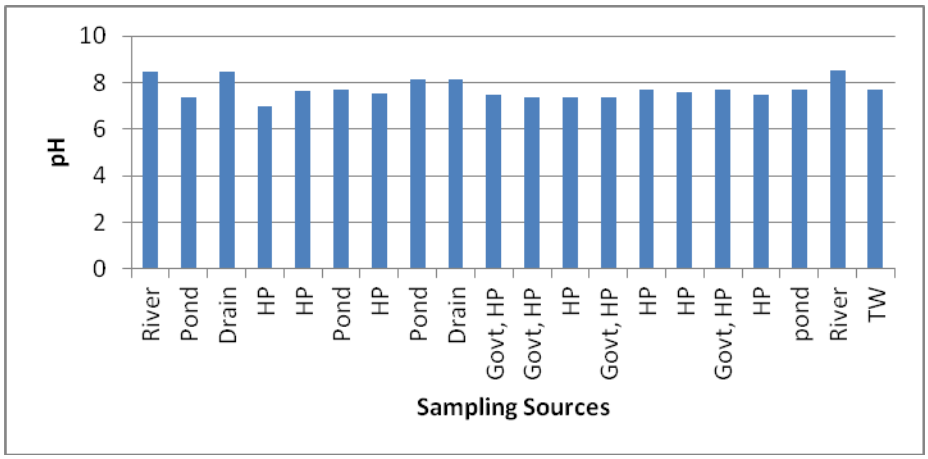


Fig.: Variation of pH for different sources in the study area

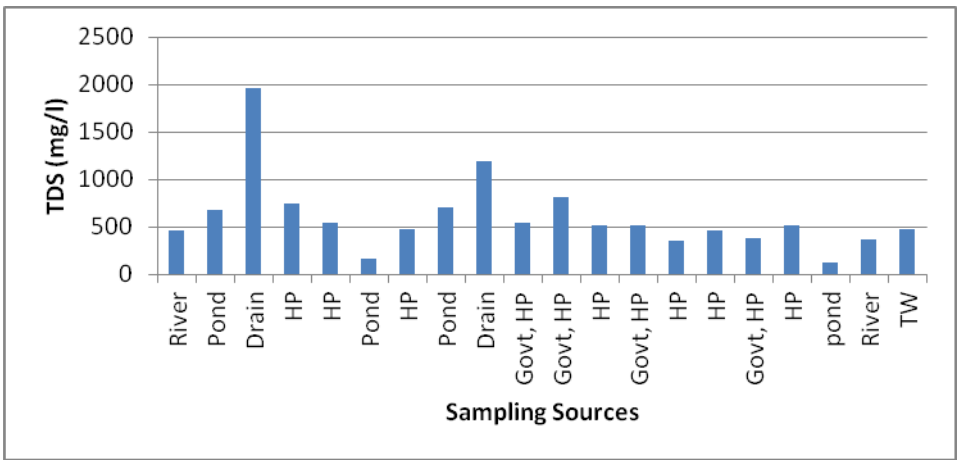


Fig.: Variation of TDS for different sources in the study area

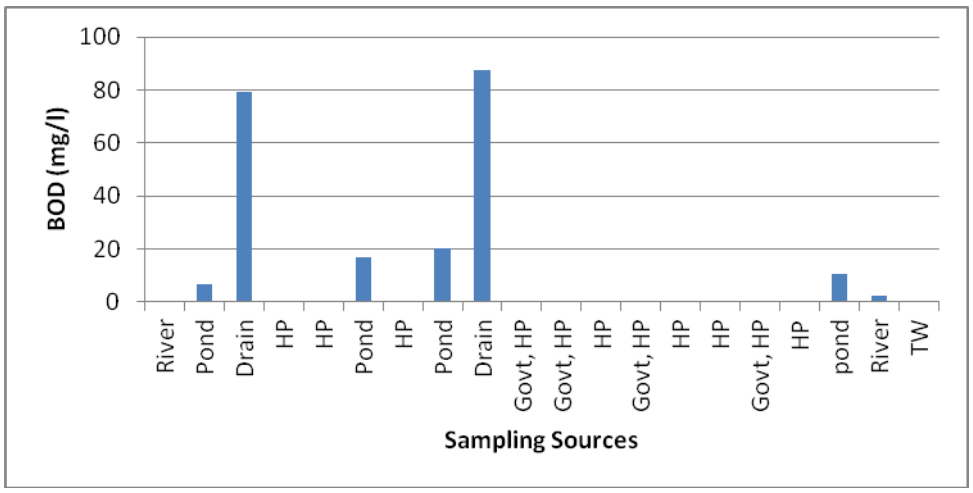


Fig.: Variation of BOD for different sources in the study area

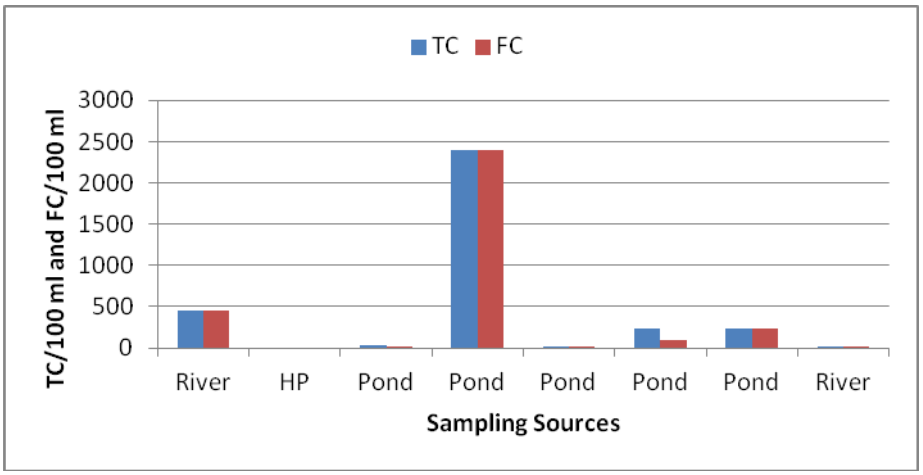


Fig.: Variation of TC and FC for different sources in the study area

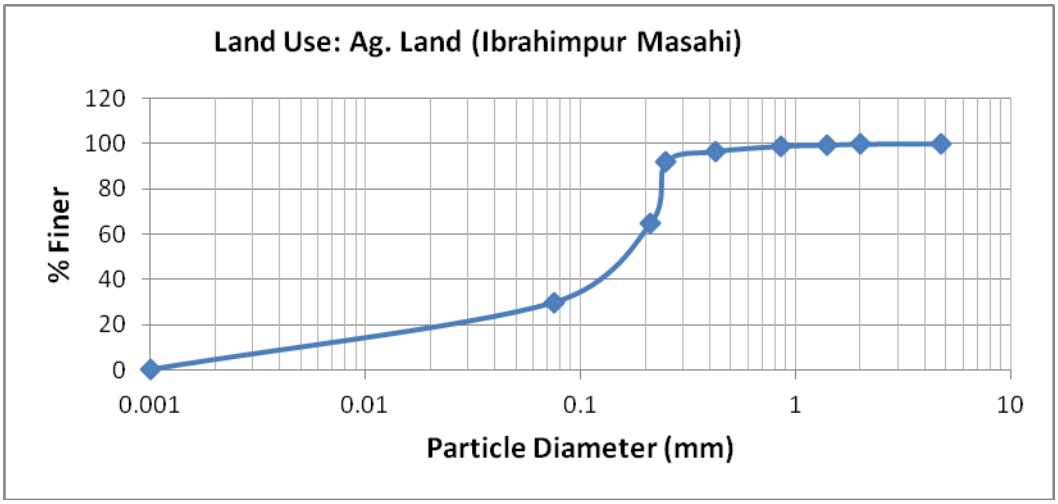


Fig.: Grain Size Distribution Curve of Soil Sample Collected From Ibrahimpur Masahi (Agriculture Land)

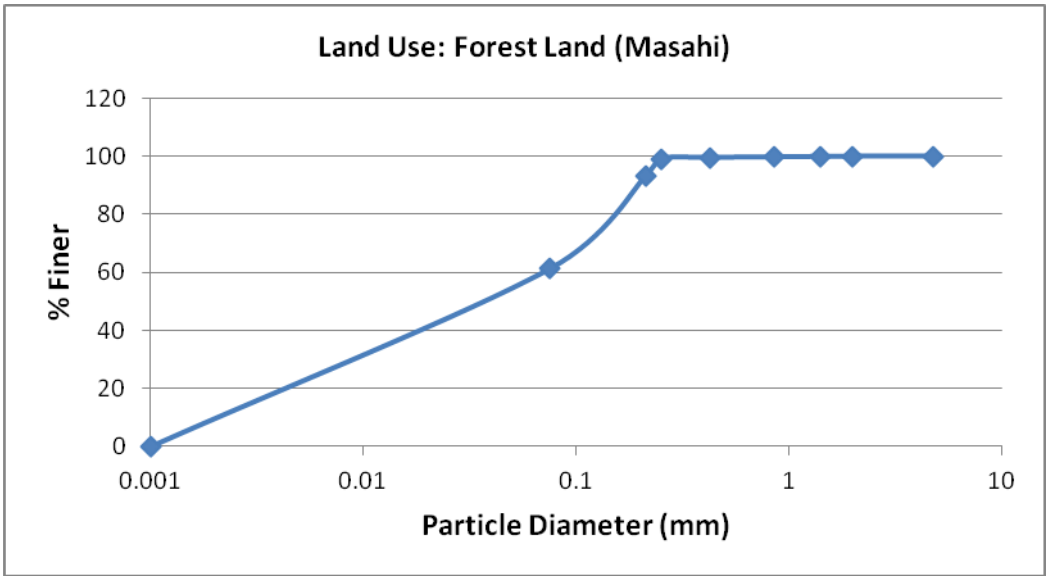


Fig.: Grain Size Distribution Curve of Soil Sample Collected From Masahi (Forest Land)

14. **End Users / Beneficiaries of the Study:** Village Panchayats and Dist. Administration

15. **Deliverables:** Technical report and papers
16. **Major items of equipment procured:** -
17. **Lab facilities used during the study:** Soil & GW Lab, WQ Lab
18. **Data procured or generated during the study:** Soil Characteristics, Water Quality, Discharge
19. **Study Benefits / Impacts:** Helpful for improving the livelihood of the local people

20. **Involvement of end users/beneficiaries:** Local people
21. **Specific linkage with Institution and /or end users / beneficiaries**: Village Panchayats
22. **Shortcoming/Difficulties:** -
23. **Future Plan:** The future Plan of the study is given below:
    - Survey of existing ponds & capacity estimation
    - Water quality monitoring and estimation of eutrophication status of ponds
    - Preparation of landuse map of the watershed
    - Estimation of surface runoff of the watershed
    - Estimation of ET
    - Identification of potential rainwater harvesting structures and preparation of water conservation plan for the village
    - Mass awareness activity on water conservation and management in the study area.

Study -3

1. **Title of the study**:

   Participatory development of structure for IWRM Framework in identified sub-basins under Pilot Basin Studies (PBS) program

2. **Name of PI, Co-PI, & their affiliations**

   Dr V C Goyal, Sc F (**PI)**, Er Omkar Singh, Sc E and Dr R V Kale, Sc B
   (Inputs contemplated from relevant professional organizations, such as SaciWaters, Hyderabad)

3. **Type of study**
   Internal

4. **Date of start:** July 2014

5. **Scheduled date of completion:** March 2015

6. **Study Area:** Six pilot basins have been selected [Yerrakalva basin (A.P.), Zuari basin (Goa), Bina basin (M.P.), Mahi basin (Bihar), Tawi basin (J&K), Kulsi basin (Assam)] in consultation with the respective state governments in which selected pilot basin is falling to address the existing water-related problems.

7. **Statement of the problem**
   It is widely accepted that basin planning must seek to obtain a balance between water resources development and water resources protection from social and cultural points of view as well as economic and environmental aspects.

   Various hydrology-related studies and activities are undergoing since 2012 in the six sub-basins identified under PBS Program of NIH. The ultimate outcome of the PBS Program is to bring out IWRM Framework for each of the sub-basins based on the hydrological studies, which would provide useful insight for sustainable development of water resources in the respective study areas. Therefore, an IWRM-based basin development strategy document is required outlining the availability of water and related natural resources, and the strategy to share, use, manage and protect the basin's resources in an equitable and acceptable way. Activities under the PBS Program should address:
   - Examining the existing water resources management system in terms of the IWRM principles and the goals of sustainable management and development.
   - Identifying the pertinent parameters of the hydrological cycle, and evaluate the water requirement of different development alternatives.

8. **Study objectives**
   The objective of the study is to prepare an IWRM Framework document outlining the availability of water and related natural resources, and the strategy to share, use, manage and protect the basin's resources in an equitable and acceptable way.

9. **Methodology**
   Through the proposed study, a document will be prepared which will provide the structure of IWRM Framework to be used for each of the six sub-basins of the

PBS Program. This document will have sections and reporting formats on the status of the basin, development trends, capacity development needs, and basin development strategy. Consultations will be held with the local stakeholders and the six sites. Professional organizations having specialized knowledge of IWRM issues (e.g. SaciWaters, Hyderabad) will be consulted/involved in preparation of the structure of the IWRM Framework document.

10. **Timeline**

S.N.	Activity	2014-15				2015-16
		Q1	Q2	Q3	Q4	Q1
1.	Compilation of IWRM Framework strategies					
2.	Preparation of draft IWRM Framework document for the PBS Program					
3.	Consultation with stakeholders on the draft document					
4.	Finalization of the IWRM Framework document					

Achievements:

Contents of the Draft IWRM Framework Document

1.0 INTRODUCTION

- Who is managing the water resources?
- Who are water resources users?
- Who is developing the water resources?
- Water resources management problems and challenges
- Why Integrated Water Resources Management (IWRM)?

2.0 WATER RESOURCES ASSESSMENT

- Physical Setting and Climate
- Surface Water Resources
- Ground Water Resources
- Water Balance Estimation
- Water Quality

3.0 WATER RESOURCES ALLOCATION AND USE

4.0 PILOT BASIN MANAGEMENT PLAN

5.0 CAPACITY BUILDING MECHANISM

6.0 INSTITUTIONAL COORDINATION MECHANISM

Study – 4

1. **Thrust Area under XII five year Plan**: Integrated Water Resources Management (Hydrology for sustainability of water resources/DSS (Planning) activities)

2. **Project team**:
   a. **Project Investigator :** Dr. Ravindra V. Kale, Scientist 'B'
   b. **Project Co-Investigator:** T Thomas (RC Bhopal), Dr Jyoti Patil
   Staff: Mr. Rajesh Agarwal, SRA

3. **Title of the Project:** Customization of WEAP model for application in Ur river watershed in Tikamgarh district of Bundelkhand region.

4. **Objectives:**
   The main object of the study is the customization of **W**ater **E**valuation **A**nd **P**lanning (WEAP) model for linking the Integrated Water Resource Management (IWRM) and hydrological inputs with livelihood issues in Ur River catchment in Tikamgarh district of Madhya Pradesh (India). This main objective of the study can be accomplished with following sub-objectives:

   1. To prepare the input data structure for WEAP model.
   2. To test the ability of WEAP model to be used as a simulation tool to perform different types of scenario analysis studies

5. **Present State-of-Art:**

   There are various hydrologic modelling tools which are designed to simulate water development and management policies in river basins. These models are applicable to wide variety of specific watershed or river basin conditions, water resource system configurations, institutional conditions, and management issues are briefly discussed. Each of these modelling softwares are based on a node-link network representation of the water resource system being simulated. Some of the models include optimization that replaces a more detailed representation of operating policies. All contain menu-driven graphics-based interfaces that facilitate user interaction.

   WEAP is a robust tool for assessment, management and planning of water resources where it simulates hydrologic pattern based on climatic input. WEAP uses precipitation, temperature, humidity, infiltration, and wind speed data to predict the amount of precipitation that falls into a particular area, discharge of streams, recharge of groundwater and/or evapotranspiration through vegetation.

   It allows to build a futuristic scenarios based on the baseline scenarios along with assumptions towards water demand, infrastructure and regulations. The assessment of the impact of all the anthropogenic activities on water resources management and livelihood issues could be possible in order to predict water shortage and water quality base on a model scenario. This software tool can be used to demonstrate the results of water demand quantity met during a month, the degree of potential water shortage, level of reservoir storage for future use and measurement of water quality. Further, it can be used to assess the adequacy of environmental flows, the level of hydropower generation capacity, the evaluation of soil moisture, evapotranspiration rates, volume of surface runoff, the rate of ground water recharge, agriculture water requirement, possible alternative to adapt cropping pattern to increase water use efficiency and maximize the income. Basically, WEAP has two main functions:

1. Simulation of natural hydrological processes (e.g. evapotranspiration, runoff and infiltration) to enable assessment of the availability of water resources within a catchment; and
2. Simulation of anthropogenic activities superimposed on the natural system to influence water resources and their allocation (e.g. consumptive and non-consumptive water demands) to enable evaluation of the impact of human water use.

In the WEAP model, in order to allow simulation of water allocation, the elements that comprise the water demand-supply system and their spatial and temporal relationships are characterized for the catchment under consideration. The system is represented in terms of its various water sources (for instance surface water, ground water, desalination, water reuse elements) withdrawal, transmission, reservoirs, waste water treatment facilities and water demands (user defined sectors but typically comprising irrigation, mines, industry, domestic water supply).

Study Area

The climate of Tikamgarh district is characterized by a hot and dry summer. The normal annual rainfall is 1057mm. About 90% of the annual rainfall is received during southwest monsoon period, i.e. June to September. The normal maximum temperature received during the month of May is 41.8° C and minimum during the month of January is 7.0°C. The normal annual mean maximum and minimum temperatures of Tikamgarh district are 32.4°C & 17.5°C respectively. The entire Tikamgarh district falls under Betwa sub-basin of Ganga basin. Dhasan, Jamni and Sadhni are perennial rivers whereas Ur, Bargi, Gorar and Supihar are ephemeral streams in the area. The overall drainage pattern in the area is dendritic.

In this study Ur River watershed having area of 990.37 km^2 is selected for the studydevelopment of DSS for the IWRM. The watershed ID and watershed code of

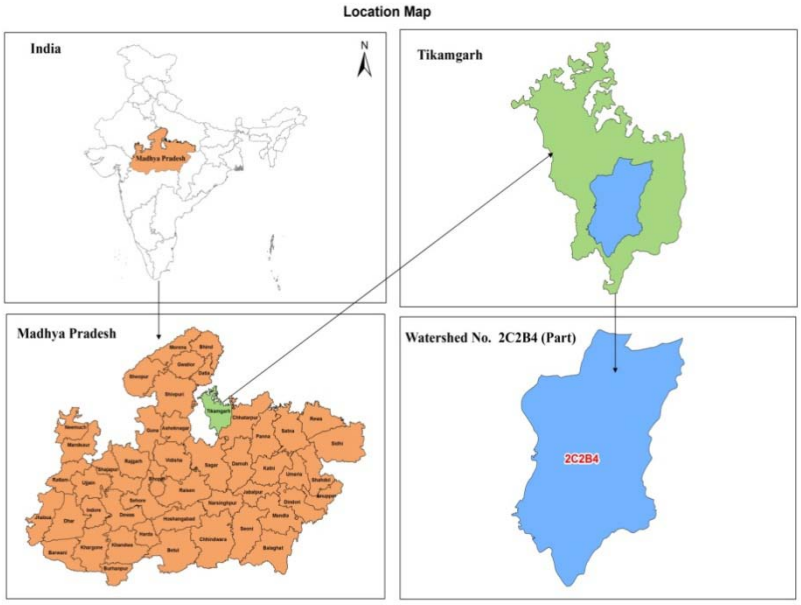


Figure 1. Location map of the Ur River catchment in Tikamgarh District (M.P.).

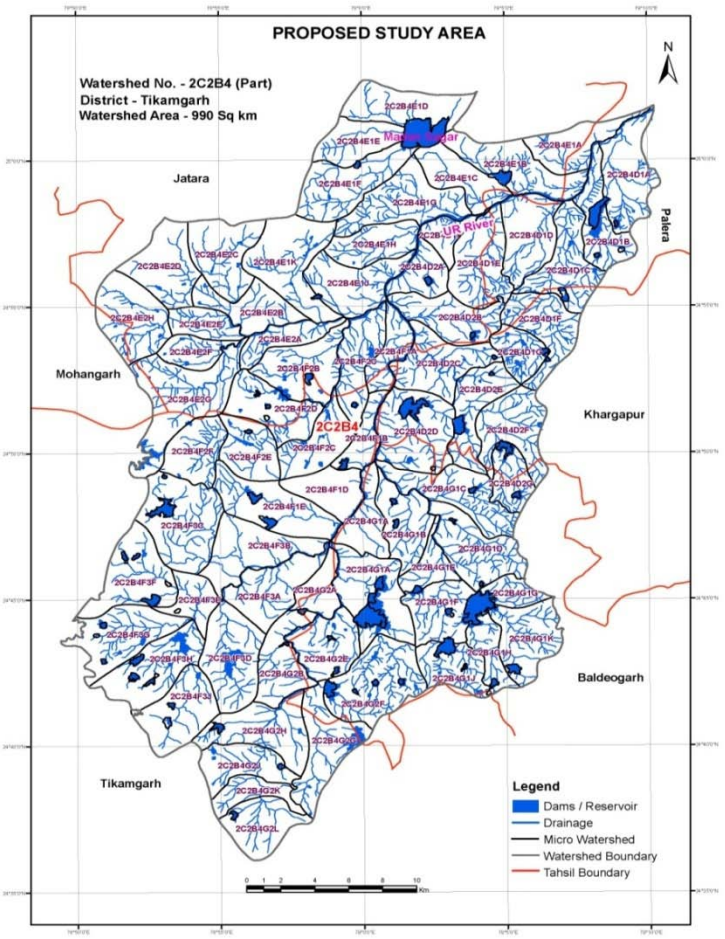


Figure 2. Map of study area showing the details of existing streams, reservoirs/dams, micro watersheds and tahsil boundaries.

the Ur watershed is 4050104 and 2C2B4E1D, respectively as per the watershed classification system adopted by the M. P. Government. The Ur River watershed falls in the Betwa-Dhasan Lower Dhasan subcatchment. The location map of this watershed is shown in Figure 1. Further, Figure 2 shows the details of existing streams, reservoirs/dams, micro-watersheds and tehsil areas covered by the study area. It covers around inhabited 200 villages in the Jatara, Tikamgarh, Baldeogarh, Kharagpur and Palera tehsils of the Tikamgarh District. Out of total area of 990.37 km^2, 11.18, 19.98, 45.58, 230.54, 69.79, 105.07, 99.68, 246.93, 34.50 and 131.28 km^2 areas are barren rocky, builtup, dense forest, double crop, fallow land, kharif crop, land with or without scrub, rabi crop, rivers & water bodies, scrub forest area, respectively.

The water sources are varied and often seasonal, ranging from ponds, tanks, lakes and streams to open wells, bore wells and irrigation canals radiating out from large-scale dams. Most agriculture is single-crop and rainfed with supplementary water from open wells. Thus, large numbers of farmers are highly dependent on the monsoon rains to recharge these wells. The geological formations in the area mainly consist of Granite/Gneiss/ Schist/Amphibolite/Gabbro and Quartz Reefs type rock formation. Therefore, the underground granite layer limits groundwater recharge. Therefore, this watershed area is having large numbers of surface water harvesting structures or shallow dug wells. But, gradually the predominantly agrarian region started depending on groundwater for irrigation.

This area has witnessed fluctuations between extremes in weather conditions– long drought spell and intense monsoon rainfall. The recent long drought followed by extreme rainfalls in the monsoon season of 2008-09 is an example. In the last eight to nine years there have been significant changes in weather patterns which have adversely affected farmers and farming. Comparing with the situation 25 to 30 years earlier, people say that rainfall has decreased, the number of rainy days has decreased, rain tends to be concentrated in a smaller number of days, and cases of untimely rain are more common (frequently harming farmers instead of helping them). The damage caused by hailstorms, frost and storms has increased.

6. Methodology

This study intended to customize the Water evaluation and Planning (WEAP) model by linking the Integrated Water Resource Management (IWRM) and hydrological inputs with livelihood issues in Ur River catchment in Tikamgarh District (M.P.).

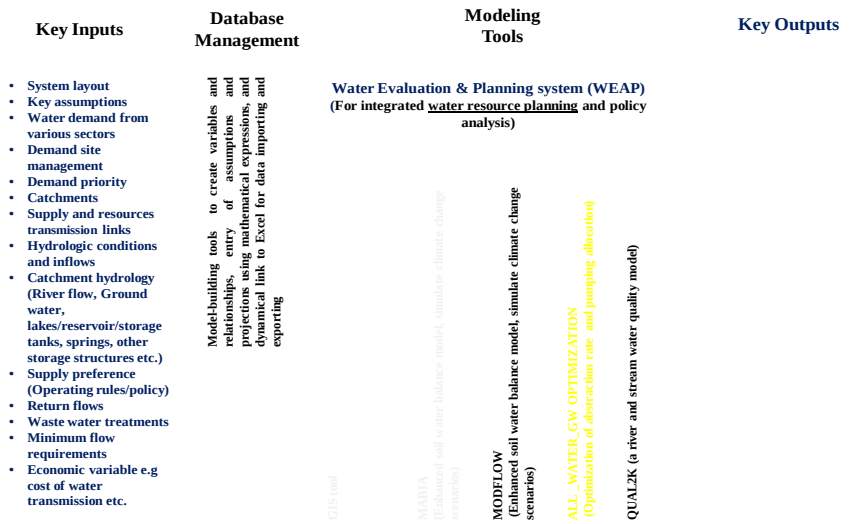


Figure 3. The WEAP model structure along with its coupling with other modeling tools to customize it for the Ur River catchment.

The WEAP model will be customized at sub-catchment scale in order to fulfill the requirements of the proposed DSS and output will be obtained on a daily/monthly scale. Prior to this, the hydrological processes occurring in the Ur River catchment will be modeled and and will be compared with the measured discharge time series. After, the proper calibration of the model, the demand sites will be added into a model framework and different scenarios will be generated to assess the gaps in the water demand and supply and water availability at different locations and at the different period of time. The following step will be followed to generate typical scenarios:

- *Current Account* year will be chosen to serve as a base year of the proposed model.
- *Reference scenario* is established from the current Accounts to simulate likely evaluation of system without inerventation.

6.1 Input of WEAP-MABIA model and its status on 11.11.2014

Sr. No.	Data		Frequency and source of data	Status
1.	**Groundwater Data**	• **Storage Capacity (MCM)** • Natural runoff • Maximum withdrawal • Aquifer storage capacity • **Ground water levels at various observation wells** • Lithology (rock types and thickness) • Aquifer map at possible finer grid size	State Ground Water/ Irrigation Department/ CGWB [Data shown in bold is the minimum requirement if empirical equations are to be used]	Under process from CGWB. Data from state ground water deptt. Collected.
2.	**Reservoir storage data**	• Storage capacity (MCM) • Initial Storage (MCM) • Net Inflow	Irrigation Departmen t/WRD	Available data collected.
3.	**Hydrological Parameters data**	• **Stream flow** • **Water level in reservoirs/tanks/ponds** • Soil moisture content in soil profile • Soil temperature in soil profile • River water temperature data for each reach • Physio-chemical data of water bodies • **Location of wells and water harvesting structures**	Daily Daily Daily Daily Monthly Monthly [Data shown in bold is the important data if only demand and supply has to be meet out]	Collection of available data is completed. No stream flow records are available and hence measurement of stream discharge data is started with advanced instruments from Sept., 2014. Measurement of Water level data in the lakes is under progress. Bathymetric survey may be planned in next month.
4.	**Land Use Data**	• Land use/Land cover map (.shp file) • Total Land Area (ha) • Share of Land Area for	GIS/SAC Year 2010 One time Yearly	LULC map and Land capability map

		different crops • Land capability • Net Sown Area for Crops (Kharip/Rabi/Dual season crop area)	season-wise data	prepared. Collection of crop data at Khasra level is under process.
5.	**Topographic and Geomorphic Features**	• DEM/Terrain (elevation and slope) • Watershed map • Drainage density map • Canal network map	GIS/SAC [Spatial data at possible finer grid size]	
6.	**Crop data**	• Crop name • Category of crop (*i.e*. cereal, legumes, oilseed, vegetable, root and tuber etc.) • Stage length i. Initial stage ii. Development stage iii. Mid season Stage iv. Late season stage • Kcb (Basal crop coefficient) • Ky (Yield Response factor) • Ky (overall) • Height of crop (m) • Depletion factor • Rooting Depth(m) - 1.Minimum 2.Maximum • Planting Date of crop	1. State Agri. Univ 2. Krishi Vighyan Kendra (KVK) . FAO56 Irrigation and Drainage – Page No.56 Crop evapo-transpiration . Literature [Crop specific information, Season wise]	Data collected
7.	**Soil properties**	• Soil type and its properties i. Saturation ii. Field capacity iii. Coarse fragment iv. Wilting point • Surface Layer Thickness (m) • Initial Moisture Depletion • Maximum Infiltration Rate (mm/day) • Soil depth • Soil texture	State Agri. Univ/Krishi Vighyan Kendra/ [One time information]	Data collected
8.	**Metrological/ Climatic Data**	• Precipitation (mm) • ETref (mm/day) • Min. Humidity and Maximum Humidity • Wind speed (m/s) • Minimum and Maximum temperature • Sunshine Duration	-Daily time series data is required from base year to ending year. Source:-	

		• Solar radiation • Pan evaporation rate	Indian Meteorological Department / KVK	
9.	**Irrigation Data**	• Reservoir operation data • Irrigation Schedule • Fraction Wetted • Irrigation Efficiency • Loss to Groundwater • Loss to runoff	Irrigation Department/ WRD [Daily/monthly data]	Available data is collected.
10.	**Yield data of each crop**	• Potential yield (kg/hectare) • Market price(Rs/Kg)	Krishi Vighyan Kendra/ Krishi Utapadan Samiti/centre [Cropwise yield for each growing season; Daily time series of market price]	Data collection completed.
11.	**Water Demand Data**	• Domestic water demand • Livestock water demand • Industrial water demand	Monthly Monthly monthly	Estimated.
12.	**Demographic and Other Parameters**	• Population density • Population growth rate • Urbanisation rate		Data collection completed.

6.2 Key Output of WEAP-MABIA Model

1. Daily simulation of transpiration, evaporation, irrigation requirements and scheduling, crop growth and yields, and estimation of reference evapo-transpiration and soil water capacity.
2. Priority –based water allocation system.
3. Estimation of depletion and available water at catchment/ agricultural field level.
4. Crop wise irrigation water demand.
5. Simulation of climate change scenarios and irrigation scenarios.
6. Crop yield under different irrigation management practices.

7. Research outcome from the project

- WEAP model will be customized for its application in Ur River watershed in Tikamgarh District (M.P.). Such model will be beneficial for the proper

management of water resources in Ur River catchment and economic and social up-liftment of the area.

8. **Work Schedule**:
   a. Probable date of commencement of the project: 1st April 2014
   b. Duration of the project: 18 months (30th September 2015)
   c. Stages of work and milestone

Sl. No.	Work Element	First Year				Second Year	
		Q1	Q2	Q3	Q4	Q1	Q2
1	Identification of site and Instrumentation at the identified site						
2	Collection of hydro meteorological data, satellite images, thematic maps etc.						
3	Compilation and verification of hydro-mertological data, baseline survey data, census data and other qualitative data						
4	Preparation of input data for WEAP model						
5	Customization of WEAP for Ur River catchment and validation of model with observed data						
6	Report writing						
	Deliverable	**1st Interim Report**				**Final Report**	

9. Work done so far

- The data pertaining to climatic variables including maximum and minimum temperature, relative humidity, wind speed, etc for the last 30 years is obtained from IMD. Collection, computerisation and processing of the rainfall and other statistical data from various organisations at Tikamgarh (completed).

- Field investigations for infiltration and hydraulic conductivity tests completed at 10 identified test sites in May 2014 and analysis is in progress.

- A field visit was carried out by the team of NIH scientists for meeting the District Collector, Tikamgarh; identification of sites/locations for installing the climate and hydrology monitoring equipments and collection of relevant data from various departments/organisations.

- A field visit has been carried out by the Project Staff for collection of soil samples and conducting field experiments on soil-water properties including infiltration and saturated hydraulic conductivity at ten locations as shown in Figure 10 in the study area based on the various crop-soil combinations.

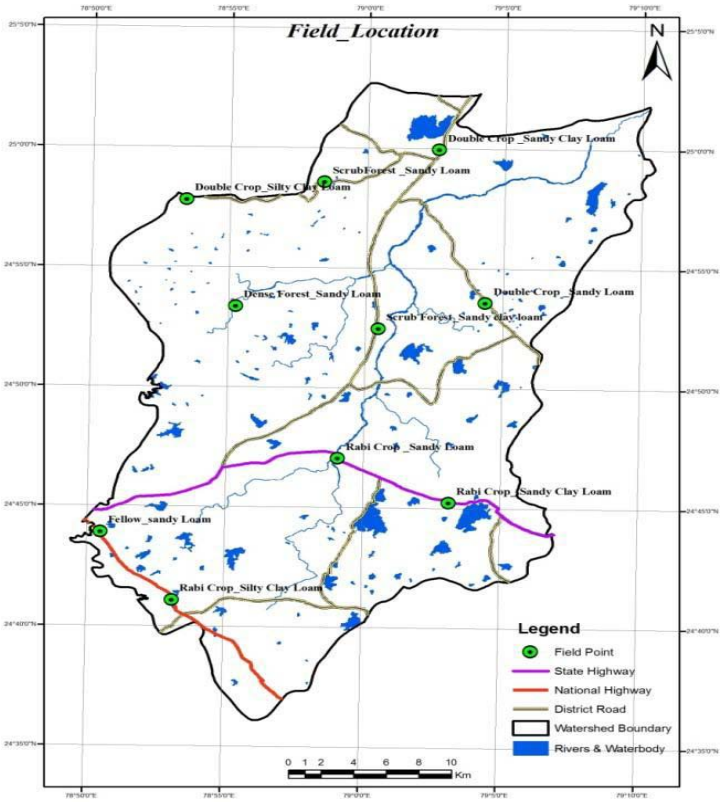


Figure 4 : Location of sites for infiltration and hydraulic conductivity tests

- A contract has been given to M/s Virtual industries Pvt. Ltd. to install various instruments and equipment to collect hydrological and climatic parameters on hourly and/or daily basis as follows

  - Automatic Weather Station (AWS) (Rainfall, barometric pressure, solar radiation, RH, wind speed, soil moisture suction)
  - Stream flow measurement
  - Pond/lake water level
  - Self recording rain gauge and non-recording rain gauge to collect real time hydro-metrological data at daily or hourly basis.

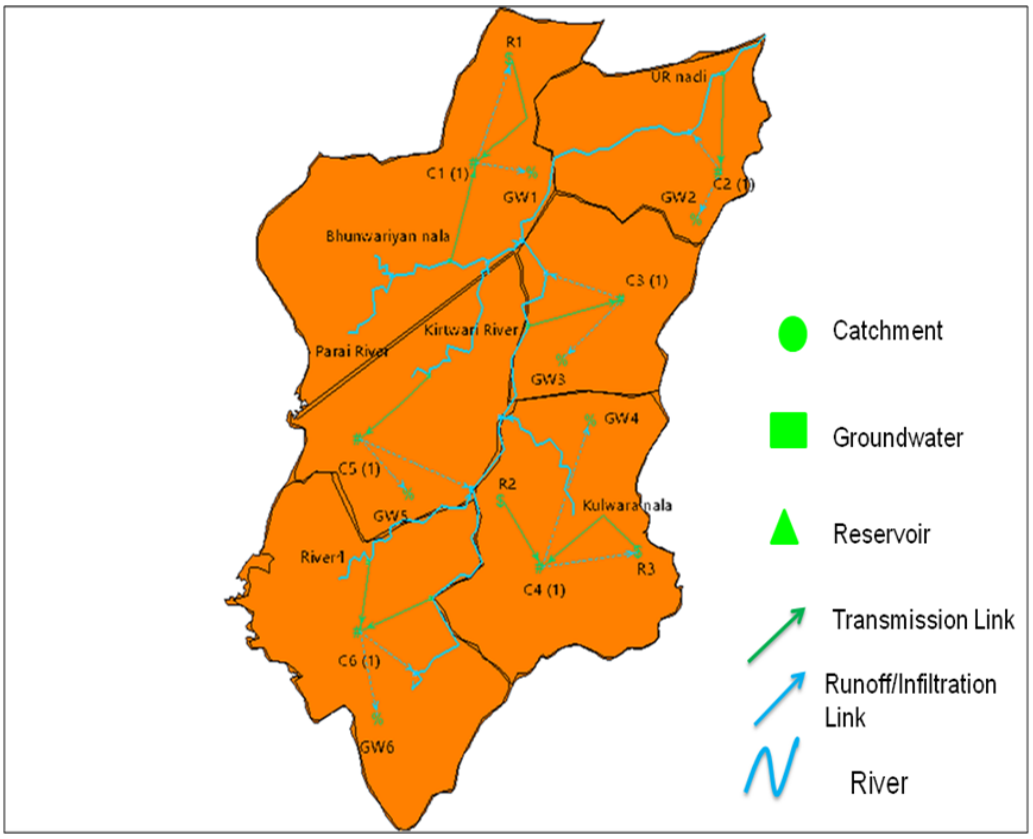
  The equipments have been installed at the identified location in the month of September 2014 and are operational

9.1 Customization of WEAP model

Customization of WEAP model has been initiated and irrigation water estimation using WEAP-MABIA module has been attempted with assumptions of the necessary input data such as monthly stream flow and input data required from ground water modeling. Preliminary analysis of agriculture water demand for Ur river watershed is given follows.

Schematic of Ur River Watershed

The Ur river catchment is sub divided into 6 sub-catchments and schematization is prepared in WEAP software is as follows:



For the catchment modeling WEAP provides the four important models: (1). Rainfall runoff (FAO) , (2). Irrigation demands (FAO), (3) Rainfall runoff (soil moisture model), and (4) MABIA (FAO 56, dual KC daily). In present study WEAP-MABIA model is tested.

9.2 Data preparation for WEAP-MABIA Modules

The WEAP-MABIA model requires data for following modules to be prepared:

- Crop module
- Soil module
- Climate module
- Irrigation module
- Yield module

9.3 Scenarios considered for WEAP-MABIA model execution

The WEAP-MABIA model is customized for Ur river watershed after dividing it in to six sub-catchments based on command area of lakes and water availability for irrigation from Ur River and its tributaries using following five scenarios:

1. Current Account (Year 2011)
2. Reference Scenario (Year 2012-2013)
3. Scenario 1: Irrigation stress for 10 days during Initial and Development stage

(Year 2012-2013)

4. Scenario 2: Irrigation stress for 10 days during Mid season stage (Year 2012-2013)
5. Scenario 3: Irrigation stress for 10 days during late season stage (Year 2012-2013)
6. Scenario 4: Deficit Irrigation at RAW (Year 2012-2013)
7. Scenario 5: Full supply of water to demand from water sources (Year 2012-2013)

9.4 **Typical Results**

9.4.1 Water demand and Unmet water demand

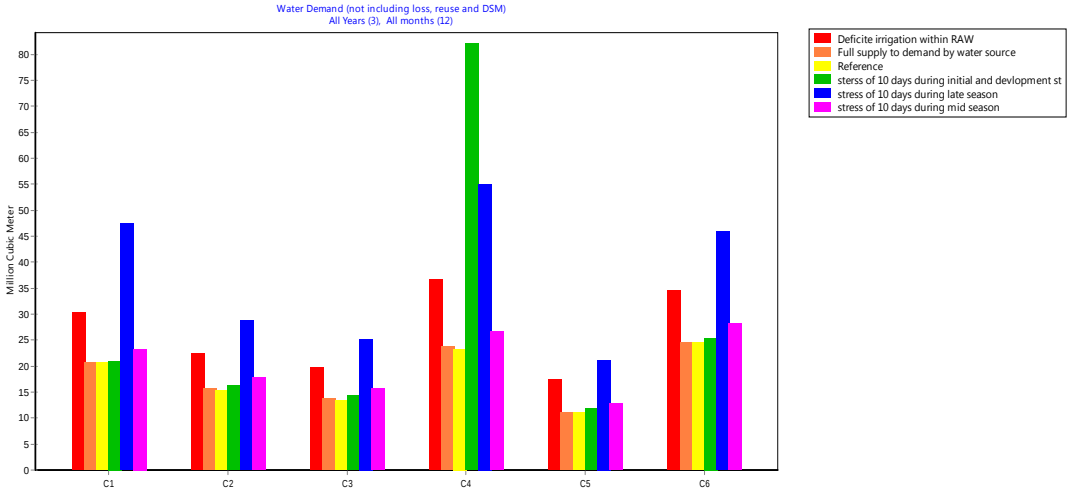


Figure 5. Water demand for different catchment of Ur river watershed for different scenario.

Figures 5 and 6, shows the water demand and unmet water irrigation demand in the six sub-watersheds of Ur River watershed under considered different water management scenarios for all three years, respectively. Figure 5 shows that there is high water demand for all the catchment when irrigation is done according to scenario 3 and scenario 4, while there will be less water demand for reference and full supply irrigation. Sub-catchment, C4 shows high water demand for scenario 1

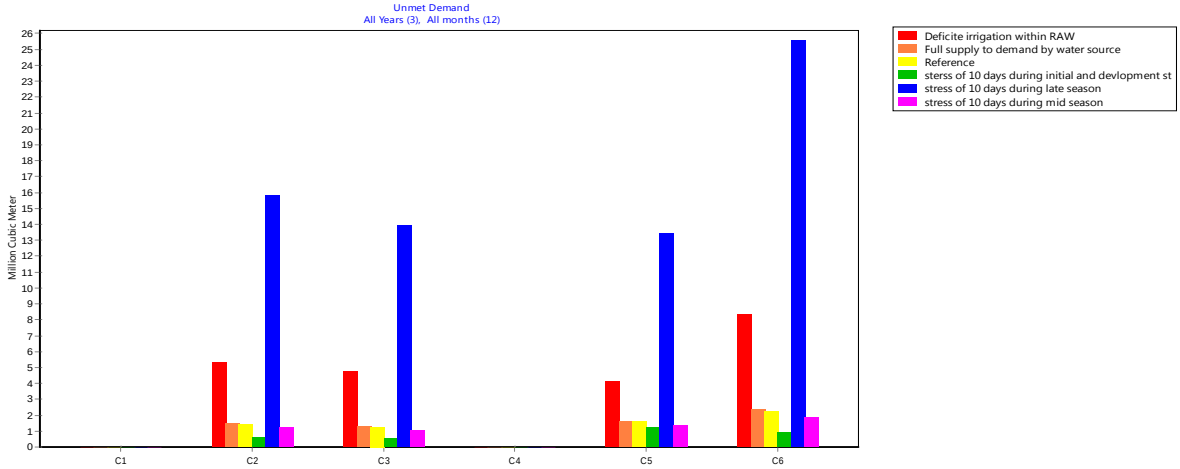


Figure 6. Unmet Water demand for different catchment of Ur river watershed for different scenario.

Figure 6, shows that if the irrigation is applied according to scenarios 3 and 4, there is very high unmet water demand for sub-catchments C2, C3, C5 and C6. Sub-catchments C1 and C4 do not show any unmet demand because there are large ponds/lakes present in these sub-watersheds to meet the irrigation water demand.

9.4.2 ET Actual and ET Potential

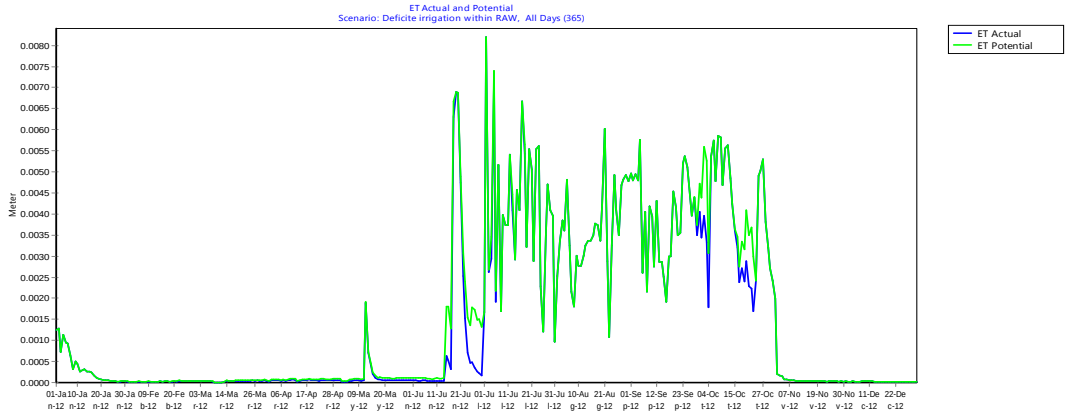


Figure 7. ET actual and ET potential for Deficit irrigation scenario.

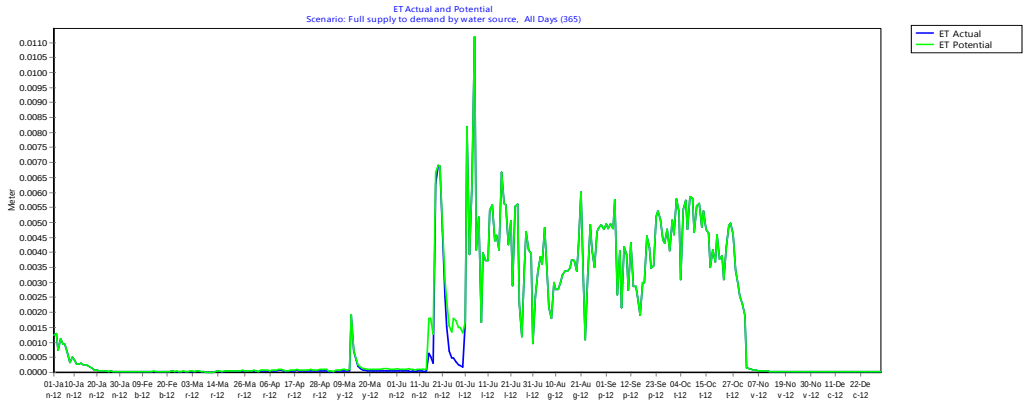


Figure 8. ET actual and ET potential for full supply irrigation scenario.

Figures 7 and 8 are showing the estimated actual ET and potential ET during year 2012 for black gram with consideration of deficit irrigation and full supply irrigation scenarios, respectively. Since in case of other water management scenarios, the conditions generally falls around these two scenarios. The curve shows that due to shortage of water in deficit irrigation the actual ET cannot meet the potential ET requirements, while in fully irrigation scenario the actual ET is almost equal to potential. However, in all scenarios, the actual ET is lower than potential ET during summer months especially in the months of May and June wheras during monsoon months the actual ET actual almost equal potential ET potential due to availability of sufficient water for evapotranspiration. Overall, the deficit irrigation scenario shows large difference in actual ET and potential ET for month of October and November during late season of crops.

9.4.3 Crop Yield

The impact of considered various irrigation water management scenarios on yield of eleven different crops grown in all the six sub-watersheds in Ur River catchment are

studied. During this study, it is assumed that the climatic conditions and irrigation facilities were identical all over the whole catchment area. For example, as shown in Figure 9, the yield of the Barley crop is highly sensitive to the soil moisture stress and results in the reduction of crop yield if the timely irrigation is not applied to the crop. It is can also be observed that crop production is more when full supply irrigation is assured whereas minimum crop yield when deficit irrigation condition exists. It can also be seen that, when there is water stress during initial and mid growing seasons, it has very slight impact on the yield of crop as compared to the full supply case whereas water stress during late growing stage have a significant impact on the barley crop yield.Similarly, results for all other crops can be examined.

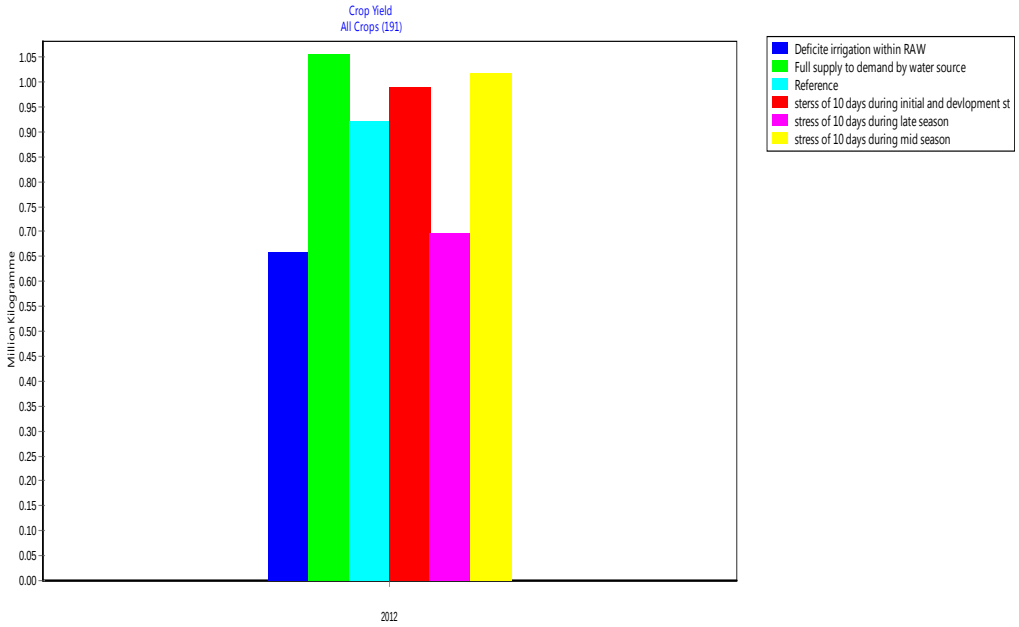


Figure 9. Crop yield of Barley crop under different irrigation scenarios.

Future work

- Monthly storage data for the lakes/tanks during various months and its release for agriculture are not available. In this regards, the water level recording for three important lakes/tanks has been already stared. In the next month, the bathymetric survey will be undertaken for these three lakes/tanks to estimate monthly availability of water storage in the tanks/lakes.

- Impact of climate change scenarios will be incorporated in WEAP model to plan irrigation water demands and other water use demands in Ur river catchment.

- The delineation of sub-watershed with use of high resolution Cartosat LISS III/LISS IV data and accurate crop data during kharif and rabi season is in under process which will be used to manage the irrigation water demand at a finer scale.

- Crop coefficients will be revised, if needed with the studies from this available watershed area.
