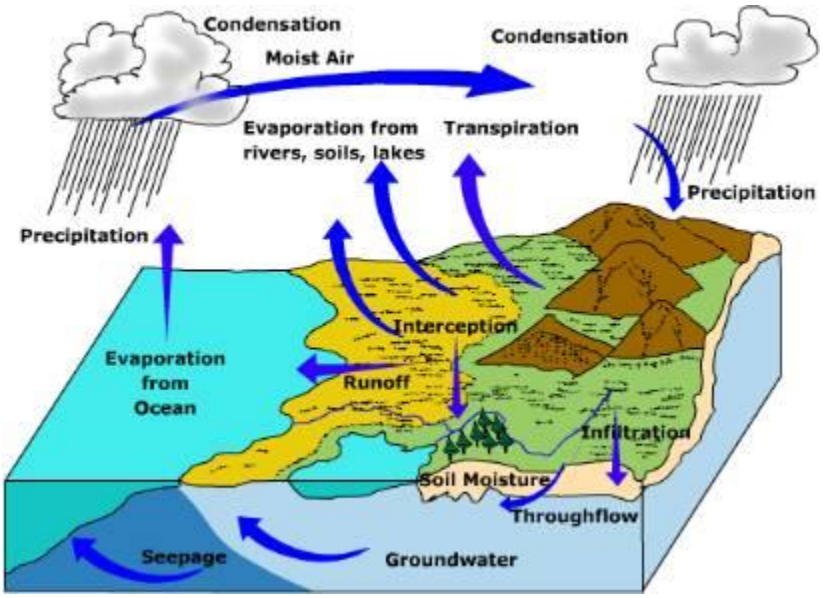
AGENDA AND AGENDA NOTES FOR THE 43rd MEETING OF THE WORKING GROUP OF NIH

DECEMBER 8-9, 2015
AT 1100 HRS



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NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

AGENDA AND AGENDA NOTES FOR THE 43rd MEETING OF THE WORKING GROUP OF NIH

AGENDA ITEMS

ITEM NO. 43.1 Opening Remarks by the Chairman

ITEM NO. 43.2 Confirmation of the minutes of 42nd meeting of the Working Group

The 42nd meeting of the Working Group was held during 19-20 March 2015. The minutes of the meeting were circulated to all the members and invitees vide letter **No. RCMU/WG/NIH-10 dated 8 April 2015**. No comments were received on the circulated minutes. A copy of the minutes of the 42nd Working Group is given in **Annexure A.**

The Working Group may please confirm the minutes.

ITEM NO.43.3 Action taken on the decisions/ recommendations of the previous Working Group meeting

During the 42nd 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.43.4 Presentation and discussion on the status and progress of the work programme for the year 2015-2016.

The approved Work Programme of the six Divisions of the Institute for the year 2015-16 has been given in the **Annexure B** in the following order**:**

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

	No. of Studies/Projects During the Year 2015-2016					
Division	**New**		**Ongoing**		**Total**	
	Internally funded	Sponsored	Internally funded	Sponsored		Consultancy Projects
Environmental Hydrology	1	-	2	2	**05**	**3**
Ground Water Hydrology	1	2	3	-	**06**	**-**
Hydrologic Investigation	2	1	5	4	**12**	**10**
Surface Water Hydrology	6	-	8	2	**16**	**-**
Water Resources System	1	2	9	-	**12**	**-**
Research Management & Outreach	-	-	3	2	**05**	**-**
Total					**56**	**13**

During the present meeting, Division-wise progress and status of the work programme for the year 2015-16 shall be presented in detail. The Working Group may please consider the progress and status of the Work Programme for the year 2015-2015.

ITEM NO. 43.5: Any Other Item with Permission of the Chair.

MINUTES OF THE
42ND MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING MARCH 19-20, 2015

The 42nd meeting of the Working Group of NIH was held at NIH, Roorkee, during March 19-20, 2015 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 42.1: 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 that the Institute has received many additional responsibilities from the Ministry of WR, RD & GR, namely- development of a Ganga Knowledge Centre; two pilot sites for demonstration of the wastewater treatment systems, including phytoremediation technique; and pilot demonstration of natural treatment techniques, such as Bank Filtration, at selected sites in the country.

A Memorandum of Understanding (MoU) was signed between National Institute of Hydrology (NIH) and Centre for Water Resources Development and Management (CWRDM), Kozhikode. The ED, CWRDM and the Director, NIH exchanged the MoU document.

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

S N	Member	Suggestion(s)
1	Dr N B N Prasad	▪ Explore new, innovative ideas ▪ Provide list of publications in the working group meeting agenda document ▪ Mention name of funding agency and budget for sponsored projects
2	Dr R Rangarajan	▪ Intensity of rainfall should be considered for modelling
3	Dr (Mrs) Surinder Kaur	▪ Emphasize on water quality studies
4	Dr S C R VIshwakarma	▪ Revisit published work, and highlight public-utility work
5	Sri Kishore Kumar	▪ Provide meta-data on NIH's website
6	Dr R D Deshpande	▪ EHD should explore plasma-based remediation techniques (contact Institute of Plasma Research, Ahmedabad) ▪ Use SAT along with MAR ▪ Improve presentations, focusing on results and time management ▪ Visibility of research results through publication of edited books, etc.

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

ITEM No. 42.2: CONFIRMATION OF THE MINUTES OF 41st MEETING OF THE WORKING GROUP

The 41st meeting of the Working group was held during November 26-27, 2014. The minutes of the meeting were circulated to all the members and invitees vide letter No. RCMU/WG/NIH-10 dated December 10, 2014. No Comments were received. The members confirmed the Working Group minutes.

ITEM No. 42.3: ACTION TAKEN ON THE DECISIONS/RECOMMENDATIONS OF THE PREVIOUS WORKING GROUP MEETING

Dr V C Goyal gave a brief account of the actions taken on the recommendations/ decisions of the 41st working group meeting.

ITEM Nos. 42.4 & 42.5: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2014-15 AND FINALIZATION OF THE WORK PROGRAMME FOR THE YEAR 2015-16.

The Member-Secretary requested the respective Divisional Heads to present the progress of studies carried out during 2014-15 and work programme for the year 2015-16. Accordingly, the progress of various studies and sponsored projects was presented by all Scientific Divisions on their turn during the 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

S.N.	Title of the Project/Study, Study Group & Duration	Recommendation/Suggestion
	Internal Studies	
1.	Water Quality Modeling using Soft Computing Techniques Study Group: Rama Mehta (PI), C. K. Jain, and Anju Chowdhary Duration: 2 Year (05/14-03/16)	Dr. N. B. N. Prasad (CWRDM) suggested that there must be some plasma based remediation. Dr. R.D. Deshpande suggested that the WQI should be done for heavy metals like Cadmium, Chromium, Zink etc. He also suggested that a software with all guidelines to calculate WQI like CCME guidelines must be developed by NIH itself.
2.	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar Study Group: Rajesh Singh (PI), C. K. Jain, M. K. Sharma, S. P. Rai, Renoj J. Thayyan and J. P. Patra Duration: 3 Years (07/14-06/17)	Dr. S.K. Bartarya, WIHG, Dehradun suggested analysis of silica and plot Na+K conc. Vs Silica concentration for silicate weathering. Director, NIH suggested correlating the water quality parameters with flow.
	Sponsored Projects	
3.	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology Study Group: Vijaya Aggarwala, IITR (PI), Rama Mehta, NIH (Co-PI) Duration: 2 Years (04/14-03/16) Sponsored by DST, New Delhi	-
4.	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 and Dayanand Duration: 3 Years (04/14-03/17) Sponsored by DST, New Delhi	-

ENVIRONMENTAL HYDROLOGY DIVISION
WORK PROGRAM FOR 2015-16

S.N.	Code	Study	Study Team	Duration
Internal Studies				
1.	EH/2015/TS-1	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) C. K. Jain	2 Years (05/14-05/16)
2.	EH/2015/TS-2	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Hardwar	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.	EH/2015/SR-1	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier **(DST)**	M. K. Sharma (PI) C. K. Jain Renoj Thayyan Manohar Arora Naresh Saini Jatin Malhotra Rakesh Goyal Karan Jamwal	3 Years (04/14-03/17)
2.	EH/2015/SR-2	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology **(DST)**	Vijaya Aggarwala, IITR (PI) Rama Mehta, NIH (Co-PI)	2 Years (04/14-03/16)

GROUND WATER HYDROLOGY DIVISION

Mr. C. P. Kumar, Scientist 'F' presented an overview and progress of studies and activities carried out by the division during the period December 2014 - March 2015. 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 sponsored projects being pursued by the Division. He informed that out of four R&D studies approved for the year 2014-15, one is in-house study and three are sponsored studies. The '*Saph Pani*' project was concluded in September, 2014 with organization of the International Conference at New Delhi. Two out of the three sponsored studies are being continued as in-house studies. Three new studies have been proposed for the year 2015-16.

The division has organized one training course on "*Groundwater Modeling using MODFLOW and MIKE SHE*" during 2-6 February, 2015 in collaboration with DHI-India. As professional scientific activities, scientists of the division have submitted/published a number of research papers in various journals/conferences and delivered lectures in various training courses during the period.

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

Project Ref. Code: NIH/GWD/NIH/11-15: **Managed Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)**

Mr. Sumant Kumar (PI) presented the study and explained about the analytical modeling and analyses of various hydrological, meteorological, hydro-geological and water quality parameters. Dr. Prasad asked about the connectivity of lakes with groundwater and his question was well answered based on the analyzed data. PI informed that, the study was under the framework of Saph Pani project and based on the study 3 technical reports have been published, treating Raipur as one of the case study.

Project Ref. Code: EU-sponsored Project no. 282911: **Flow and Contaminant Transport Modeling of Riverbank Filtration.** - After October 2014 as internal study.

Ms. S.P. Indwar (PI) presented the study," Flow and Contaminant Transport Modeling of Riverbank Filtration", its objectives, statement of the problem; water quality analyses results.The Conceptualization of the flow model has been completed and Steady-state modelling of flow path for monsoon (23.08.12) and post-monsoon (11.10.12) is completed. PI was advised to carry out the further data analysis of water quality and to model the bank filtrate travel-time using MODPATH and composition of extracted water in each Infiltration wells through ZONEBUDZET tools of Visual MODFLOW.

Project Ref. Code: NIH/GWD/NIH/14-17: **Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin**

Dr. Anupma Sharma (PI) presented the progress of the study initiated in Dec. 2014 in the Yamuna-Hindon Inter-basin. Declining groundwater levels and presence

of harmful contaminants in some portions of the shallow groundwater system were shown as the major issues that need to be addressed in the study area. The project budget was also presented. Dr. Prasad opined that the study objectives were complex given the time frame of the study. PI informed that existing data from different studies pertaining to various portions of the region was being utilized in the project in addition to the laboratory experiments and planned field surveys in the region.

Project Ref. Code: NIH/GWD/NIH/15-18: **Development of Website and e-Portal on "Mitigation and Remedy of Arsenic Menace in India"**

Mr. C. P. Kumar informed that Inter-Ministerial Group (IMG) on "Arsenic Mitigation" constituted by the Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India has desired that National Institute of Hydrology (NIH), Roorkee should take lead role on R & Ds activities related to "Arsenic Mitigation" as per the areas suggested by the 'Core Committee' on "Mitigation & Remedy of Arsenic Menace in India". One of the recommendations by the 'Core Committee' is website and e-Portal development on Arsenic related matter for information dissemination as well as gathering responses and opinions. Mr. R. D. Singh, Chairman also informed about background for taking-up this task. Mr. Kumar further informed that NIC will be contacted to get the website/e-Portal designed by its empanelled vendors and also the domain name (gov.in) will be registered. Necessary hardware and software will be procured and the website is proposed to be hosted on a dedicated NIH server. However, Mr. Kishore Kumar suggested to consider hosting the website on NIC server in view of security concerns.

Project Ref. Code: NIH/GWD/NIH/15-16: **Diagnosis Survey and Selection of Suitable Sites for Development of Riverbank Filtration Demonstration Schemes in Different States**

Dr. Surjeet Singh (PI) made a presentation on river bank filtration study on diagnosis survey and selection of suitable sites. Dr. C. Rangarajan, NGRI inquired about the possibility of aquifer clogging which was well replied and Sh. R.D. Singh, Director, NIH inquired about the status of RBF project to be submitted to MoWR, RD & GR. No specific observations/comments were made.

Project Ref. Code: NIH/GWD/NIH/15-16: **Alternate Water Supply Management Strategies in Arsenic Affected/ Vulnerable Areas: Mapping of Arsenic Affected Zones/ Regions in Eastern U.P.**

Mr. Sumant Kumar (PI) presented the objectives, methodology and expected outputs of the proposed study. It was advised by Dr. Deshpande that objectives should be curtailed down and PI agreed upon that. PI informed that this study was undertaken in the light of the recommendations given by Inter-Ministerial Group (IMG) on "Arsenic Mitigation" constituted by Ministry of Water Resources, River development & Ganga Rejuvenation and Public Accounts Committee(PAC, eighth report, 16th Lok Sabha) on 'Water Pollution in India'. It was informed that the proposed study will be a step forward in understanding the root causes and magnitude of arsenic contamination in eastern U.P. and for attaining sustainable supply of arsenic safe groundwater to affected areas.

The work program of the division recommended for the year 2015-16 is given below.

GROUND WATER HYDROLOGY DIVISION
WORK PROGRAM FOR 2015-16

S. No.	Code	Study	Study Team	Duration & Status
1.	GWH/2015/TS-1	Flow and Contaminant Transport Modeling of Riverbank Filtration	Shashi P. Indwar (PI) N.C. Ghosh Anupma Sharma Rajan Vatsa	3 ½ years (04/12 – 09/15) Status: In progress
2.	GWH/2015/TS-2	Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin	Anupma Sharma (PI) Deepak Kashyap, CED, IITR (Technical Advisor) N. C. Ghosh M K Sharma R.P. Singh Sumant Kumar Shashi P. Indwar	3 years (12/14 – 11/17) Status: In progress
3.	GWH/2015/TS-3	Development of Website and e-Portal on "*Mitigation and Remedy of Arsenic Menace in India*"	N. C. Ghosh (Coordinator) C. P. Kumar (PI) Anupma Sharma Shashi P. Indwar Sanjay Mittal	2.5 years (04/15 – 9/17) Status: New
4.	GWH/2015/TS-4	Diagnosis Survey and Selection of Suitable Sites for Development of Riverbank Filtration Demonstration Schemes in Different States	Surjeet Singh (PI) N.C. Ghosh C. P. Kumar Sumant Kumar Sanjay Mittal	1 year (04/15 – 3/16) Status: New
5.	GWH/2015/TS-5	Alternate Water Supply Management Strategies in Arsenic Affected/ Vulnerable Areas: Mapping of Arsenic Affected Zones/ Regions in Eastern U.P.	Sumant Kumar (PI) & Shashi P. Indwar (PI) N. C. Ghosh R. P. Singh Rajesh Singh S. L. Srivastava	1 year (04/15 – 3/16) Status: New

HYDROLOGICAL INVESTIGATIONS DIVISION

Dr. Sudhir Kumar, Scientist G and Head, presented an overview and progress of studies and activities carried out by the Hydrological Investigations Division during the year 2014-15. He informed that out of 8 internal R&D studies approved for the year 2014-15, 2 studies have been completed (out of which 1 study was completed

till last working group meeting). Out of the 5 sponsored studies, one study on sponsored by BGS, UK has been successfully completed, while 4 studies are being continued. He further informed that the scientists of the division have also completed 5 consultancy projects, conducted 5 training programs / workshops and published more than 45 papers in Journals and conferences.

Dr. Sudhir Kumar informed that for the next year, i.e., 2015-16, 5 internal studies, 4 sponsored projects, and one consultancy project shall continue from the year 2014-15. Further, 2 new internal studies and 1 sponsored project has been proposed for the year 2015-16. Also, many consultancy projects have been submitted by the scientists of the division and expected to be started during 2015-16

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

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

Head, HI Division informed that the study was being conducted in collaboration with Punjab University, Chandigarh. He told that due to some administrative problems Punjab University could not complete the component of work assigned to it. However, as NIH component of the project was completed in September 2014 and presented in the 41st working group meeting. The study has been completed and the report is being prepared.

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

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

The study was presented by Dr. S. D. Khobragade, Sc-E and PI. He informed that the study has been completed. He told that the major objectives of the study were: (i) To study inflow regime of the lake, (ii) To study seepage losses from the lake, (iii) To analyze long term trends in rainfall and evaporation, and (iv) To study water availability in the lake. All the objectives have been achieved. However, he informed that the work related to trend analysis has been done based on trend line only and analysis based on statistical tests would be completed in next few days and would be included in the final report.

Dr. Khobragade presented the analysis carried out so far and the results in details including the water balance of different years including monsoon 2015. He discussed the relative significance of various factors in the water balance of the lake. He also presented the analysis of variation of the lake water levels and analysis of catchment requirement vis-a-vis cumulative number of check dams to demonstrate the possible impact of the check dams on inflow to the lake. He informed that since in the water balance approach seepage was determined indirectly, to confirm seepage losses from the lake a number of parameters such as piezometer water level variation, radon, stable isotopes, EC, pH and temperature were measured. He presented the results of these parameters to demonstrate seepage from the lake. However, he informed that long term data and further investigations are needed for detailed analysis of seepage. In the end Dr. Khobragade presented the various findings of the study.

The working group noted the progress of the study and appreciated the work done under the study. Dr. Deshpande suggested that the water balance results may be presented as normalised data. The study has been completed and report is being prepared

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

Dr. Sudhir Kumar (PI) informed that progress of the work done upto November, 2014 was presented in the last meeting wherein it was informed that analysis of the noble gases for 12 samples has been completed from IAEA Vienna and that the results indicated a good correlation between the age of groundwater with built up of He in the groundwater. He further informed that the next phase of sampling has been started only recently and is still under progress. The results of analysis of the collected samples of this phase are yet to be obtained. Working group noted the progress of the work done under the study. No comments were received.

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

Title of the Study: **Estimation of Radon Concentration in Water and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes**

Sh. S. K. Verma, Sc. D and P.I. of the study, presented the study before the members of the WG meeting. He mentioned about the objectives of the study along with the location of study area, brief methodology, action plan, achievement so far received for the study etc. He also mentioned that there were no comments or suggestions raised during the last working group meeting i.e. 41st meeting of working group held during Nov. 26-27, 2014.

While discussing the progress of the study, he informed that 1st objective of the study has been partially achieved. The groundwater samples collected from intermediate/deep tube wells from 5 districts located in the study area have been analyzed for radon concentration. The radon concentrations monitored in these districts were found well below the maximum permissible limit for drinking water as per the guide lines of WHO. A small part of the study area is left to be investigated for radon measurement which will be taken up during the next field trip. Sh. Verma further informed that in order to meet 2nd objective of the study, a total of 19 groundwater samples have been analyzed for environmental tritium in the laboratory and the analysis of environmental tritium in rest of the 20 groundwater samples is in progress to identify the location for carbon dating.

The working group noted the progress of the study. No comments were received.

5. 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**

Dr M. S. Rao as a PI of the study informed that the study is a new study. The objectives and methodology of the project were presented in the last meeting. The study was supposed to start from 1st January, 2015 but due to technical reasons it shall now be started as a new study from 1st April, 2015. The working group noted the progress of the study. No comments were received.

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

Title of the Study: **Isotopic investigation of benchmark Himalayan glaciers**

Dr M. S. Rao, PI of the study, informed that the study was supposed to start from 1st January, 2015 but due to technical reasons it shall now be taken up as a new study from 1st April, 2015. The working group noted the progress of the study. No comments were received.

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

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

The study was presented by Sh. P. K. Garg, Scientist-B and PI. He informed that the objectives of the study are: (i) Mapping the spatial distribution and temporal fluctuation in radon levels in groundwater in Haridwar district, (ii) To investigate the effect seasonal groundwater levels fluctuations on fluctuation in radon levels. He told that the groundwater samples from the study region are being collected and analyzed for radon concentration during pre 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. He further informed that the samples are also being collected and analyzed for stable isotope analyze to support and collaborate the results and the inferences of radon measurements.

Discussing the progress of the study he informed that samples have been collected (shallow depth= <50 m) from six locations and radon analysis has been completed. Other parameters such has pH, EC, and temperature have also been measured. Results indicate that the values of radon concentration in shallow groundwater samples is within the permissible limits as prescribed by USEPA (1991).

SPONSORED PROJECTS:

8. 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

Dr M. S. Rao, PI of the project informed that the BGS funded project had two components; (i) preparing a review report by collating data from the published reports and (ii) groundwater dating using CFC & noble gas technique in Bist Doab region. The results of the report are presented in 4 publications (3 international conferences and 1 in international journal). Dr Rao informed successful completion of the project during September 2014.

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

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

Based on results of stable and radio-isotope, Dr. S. P. Rai presented the progress study. The main highlights of the presentation were the identification of recharge source of the shallow and deeper groundwater aquifer. On a query from Dr. R. D. Deshpande, Dr. S. P. Rai informed about details of the study area and it fall with the north western India and further pointed out that GRACE satellite data has been used for same area. Dr. S. K. Bartarya asked about the source water of groundwater in study area and Dr. Rai replied that findings of the study indicate about the recharge from local precipitation and recharge through the canals.The working group noted the progress of the study and appreciated the progress of the study.

10. 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

Dr M. S. Rao, P. I. of the project presented the progress of project. Dr Rao presented the 'Local Meteoric Lines' analyzed and developed for sites at Mukerian, Dasuya, Bolath, Bhaddi, Ropar, Kapurthala, Dholwaha and Maily using isotopic data of rainfall data measurements made for 2 years period. The LMWL displayed an unusual high slope ~10 for precipitation data at Mukerian. At other sites, the slopes of LMWL were in the range 7.5 to 8.5. The intercept of LMWL at these sites ranged from +5 to +15. During the study, isotopic fluctuation of reservoir water at Dholwaha and Maily dams were also compared with Bhakra reservoir water (measured on Satluj river at site Ropar). The comparison made over 2 years indicated altitude effect (depleted isotopic composition of Bhakra water ($\delta^{18}O$ = -10‰) compared to Dhowaha and Maily dam water ($\delta^{18}O$ = -3‰) and impact of local effects (evaporation, local rainfall etc) in affecting the isotopic composition of the reservoir water. Being very large in size compared to Maily and Dholwaha dams, the isotopic composition of Bhakra reservoir water fluctuated over a narrow range (< 10%) compared to large fluctuation observed in isotopic values of –Dholbaha and Maily reservoir water (>50%). The parameters- EC & $\delta^{18}O$ of Bhakra water were found correlating positively indicating changes in $\delta^{18}O$ value of Bhakra water as mainly due to evaporation effect. However, no specific relation was observed between EC and $\delta^{18}O$ for Maily dam. In addition to isotopic

investigations, groundwater level trend was also analyzed for over 20 sites for the period 1999 to 2009. The analysis indicated depleting groundwater conditions in more than 80% of the study region (the groundwater falling trend is not observed in the northern region and in area close to Ropar). The average groundwater fall rate in the region was ~1m/yr.

PI Informed that the sampling and analysis will be continued for the pre-monsoon and post-monsoon of 2015.

Dr R. D. Deshpande, member, Working Group suggested to re-confirm the isotopic slope of 10 for LMWL observed at Mukerian as the observed slope is un-usual and is not reported in the literature.

11. 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**

Dr. S. P. Rai presented the progress of the study. He informed that rainfall, river, canal and groundwater samples were to collect from the study area and stable isotopes (δD and δ^{18}O) radioactive isotope (^{3}H) were measured. The results of the isotopes were presented in detail along with details of hydrogeological conditions. Dr. Rai also presented findings of surface water groundwater interaction and origin of groundwater of the study area. Results of modelling approach to assess the base flow component were also discussed. Dr. Rai also presented the chemical analysis of groundwater data and its interpretation for origin of groundwater. Dr. Rai showed that finding of chemistry also corroborated the isotope data. Dr. S. K. Bartarya suggested to analyse SiO_2 if possible, which can help to understand silicate weathering pattern. The working group noted the progress of the study and appreciated the progress of the study.

12. 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

Dr. Sudhir Kumar (PI) informed that after the progress which was reported in the last meeting, next phase of sampling has been started only recently and is still under progress. The results of analysis of the collected samples of this phase are yet to be obtained. Working group noted the progress of the work done under the study. No comments were received.

NEW STUDIES:

1. PROJECT REFERENCE CODE: NIH/HID/SPON/12-15

Title of the Study: Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques

Dr. S. P. Rai, PI, informed that this study is being proposed under the NMSHE project which is under the process of finalization by the Institute as a sponsored project by DST. The study would be started once the project is

approved. The objectives of the proosed study would be : (i) Isotopic characterization of precipitation and identification of sources of vapour, (ii) Runoff generation processes in headwater region of Ganga using isotope and modeling (iii) Spatial and temporal variation of snow and glacier melt in Ganga and its major tributaries. (iv) Contribution of transient groundwater and its role in sustainable flow of Ganga and (v) Groundwater dynamics in mountainous area including identification of recharge sources and zones of major springs

2. PROJECT REFERENCE CODE: NIH/HID/INT/2015-16/1

Title of the Project: Status Report on Rewalsar Lake, Himachal Pradesh

Dr. Khobragade, PI, presented the study. He informed that this is a new study which is being proposed by the division. The proposed objectives of the study are : (i) To determine the environmental status of the lake (ii) To identify major problems of the lake (iii) To identify major management issues of the lake (iv) To review current research status and research needs for lake and (v) To review the data availability scenario and identify data gaps vis-a-vis identified research needs. He informed that the Rewalsar lake is significant from religious, cultural and tourism purposes but water quality degradation has been reported for the lake and due to pollution more than 700 lake fish died during May 2014. So in the first phase a status report is being proposed and based on the recommendations of the status report, of the lake, a full ledged study would be proposed in the future. He informed that the proposed budget of the study is 3.27 lakhs. While discussing the methodology, he informed that the envisaged objectives will be achieved through collection, processing and analysis of the available data, review of literature, field survey, interaction with management authorities and local people and collection and laboratory analysis for water sample/sediment samples for water quality and isotopic characteristics. Informing about the outcome of the study he told that the output of the study would be in the form of a comprehensive report wherein all data, maps, information and analysis would be included. The report would also contain major identified problems of the lake, current research status of the lake, identified data gaps. Major management issues related to the lake would be discussed and possible approaches to deal with them would be suggested.

Working Group approved the proposed study. No specific comments were received.

3. PROJECT REFERENCE CODE: NIH/HID/INT/2015-18/1

Title of the Project: Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh

The study was presented by Dr. S. D. Khobragade, Scientist E. He informed that Sukhna Lake in Chandigarh faces water scarcity problems especially during the deficit rainfall years. No studies on the interaction of the lake with surrounding groundwater have been reported for the lake so far except for the preliminary investigations carried out by NIH. Studies on water balance carried out by NIH indicated that seepage may be a significant factor determining the water availability in the lake. As such studies on seepage was

one of the major observation of the water availability studies on the lake carried out by the Institute. Therefore, the present study has been proposed with the major objective of understanding the lake-ground water interaction regime of the lake and to determine seepage losses from the lake. While discussing the methodology he informed that it is proposed install few piezometers in the vicinity of the lake as adequate ground water data are presently not available for the lake. Dr. Sudhir Kumar, Scientist-G & Head, HI Division informed that efforts would be made to model the lake-ground water interaction. Dr. Khobragade informed that the proposed budget of the study is 59.59 lakhs.

Working Group approved the proposed study. However, Dr. Prasad suggested that the first objective may be modified and identification of zones of lake-water interaction may be removed from the objectives as it would not be possible to establish such zones.

HYDROLOGICAL INVESTIGATIONS DIVISION
WORK PROGRAM FOR 2015-2016

S. N.	Code	Study	Team	Duration/ Status
	Ongoing Internal Studies			
1.	HI/2015/TS-1	Isotopic 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 CGWB, Lucknow CGWB, Chandigarh	**2 years** (07/13-06/15)
2.	HI/2015/TS-2	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)
3.	HI/2015/TS-3	Interaction between groundwater and seawater along the northern part of east coast of India	M. S. Rao (PI), Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16)
4.	HI/2015/TS-4	Isotopic investigation of benchmark Himalayan glaciers.	M. S. Rao (PI) S.P. Rai, Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16)
5.	HI/2015/TS-5	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)
	New Internal Studies			

S. N.	Code	Study	Team	Duration/ Status
6.	HI/2015/TS-6	Status Report on Rewalsar Lake, Himachal Pradesh	SD Khobragade (PI) Sudhir Kumar, C. K. Jain	**1 year** (04/15 – 03/16)
7.	HI/2015/TS-7	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	SD Khobragade (PI) Sudhir Kumar, Senthil Kumar, Pankaj Garg	**3 year** (04/15 – 03/18)
	Sponsored Projects			
8.	HI/2015/SR-1	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates **(MoES)**	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** (06/12-03/16) **Continuing Study**
9.	HI/2015/SR-2	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India **(IAEA)**	M. S. Rao (PI) C. P. Kumar S. P. Rai	**3 years** (09/12-08/15) **Continuing Study**
10.	HI/2015/SR-3	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques **(IAEA)**	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**
11.	HI/2015/SR-4	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains **(IAEA)**	Sudhir Kumar (PI) S. P. Rai S. D. Khobragade C. K. Jain P. K. Garg	**2 years** (05/13-04/15) **Continuing Study**

S. N.	Code	Study	Team	Duration/ Status
12	HI/2015/SR-5	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques **(DST)**	Dr. S. P. Rai (PI) Dr. Sudhir Kumar Rajesh Singh S. D. Khobragade Dr. M. Arora Dr. R. J. Thayyen Sh. P. K. Garg	**5 years (4/15 – 3/20) New Study**

SURFACE WATER HYDROLOGY DIVISION

S.N.	Title of Project/Study, Study Team, Start/ Completion Dates	Status and Recommendations/ Suggestions
1.	Sedimentation Studies for Pong Reservoir, Himachal Pradesh Team **A. R. Senthil kumar** Manohar Arora Suhas D Khobragade Avinash Agarwal and Sanjay Jain DOS:April 2012 DOC: March 2015	Dr N B N Prasad suggested to derive the elevation-area-capacity table for every 5 and 10 years and observe any reduction in the rate of sedimentation in the reservoir after soil conservation practices in the catchment. Dr. R. D. Deshpande inquired about the contribution of sediment yield from small tributaries joining the reservoir, which was replied by the PI. The PI requested six months extension for the computation of elevation-area-capacity table for the consolidated sediment volume for each ensemble, which will present a range of elevation-area-capacity table. The Chairman granted the permission to compute the elevation-area-capacity tables and the present the whole result in the next working group meeting.
2.	Study of Hydro-Meteorological Droughts For Chitrakoot Bundelkhand Region In India **R.P. Pandey** DOS: April 2012 DOC: March 2015	The Working Group was informed about the details of Simple Drought Index (SDI), a new method, devised and validated for regular drought monitoring using monthly rainfall data. It was reported that a comprehensive plan for augmenting drinking water supply and supplemental irrigation water supply to kharif crop during dry spells has been prepared.
3.	Application of DSS (P) for Integrated Water Resources Development & Management **Team** A.K. Lohani, Surjeet Singh, Rahul Jaiswal; D K Sonkusale and Akilesh Verma DOS: April 2013	Dr Lohani mentioned that the DSS (P) software has been developed under HP-II and the same model is being applied in Arpa basin of Seonath river basin to demonstrate the capabilities of the DSS(P) model. Dr Lohani mentioned that the crop water requirement data is not yet provided by the Water Resources Department, Raipur and therefore about six month extension may be granted to complete the study. Members and the Chairman, of the working group have approved the six month extension.

	DOC: March 2015)	
4.	Quantitative assessment of uncertainties in river discharge estimation **Team** Sanjay Kumar and Sharad Jain DOS: April 2013 DOC: March 2016	Dr. Sanjay Kumar mentioned that review comments received from the nominated experts of member countries have been resolved and the draft was circulated to member bodies and national committees for further comments. Dr. Kumar informed that comments from member bodies/national committees are currently being resolved. The final draft would be placed in the ISO meeting scheduled during May 2015 in Tokyo. There were no comments from the WG members.
5.	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills **Team** Avinash Agarwal, Manohar Arora and R K Nema DOS: Nov 2013 DOC: Oct 2016	Dr. Agarwal informed that rainfall-runoff-sediment model with using SWAT and CCH1D is in progress. Working group accepted the study progress.
6.	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P. **Team:** J.V.Tyagi and YRS Rao DOS: April 2014 DOC: March 2015	Dr. J.V. Tyagi informed that the required spatial database and attribute data tables for the model have been prepared and SWAT has been set up for the Yerrakalva basin. The model calibration is pending for want of the out flow data from the Yerrakalva reservoir. In view of this, Dr. Tyagi requested the Chairman to grant an extension of six months to complete the study. The Chairman approved the extension for the study up to up to 30th September, 2015.
7.	Systematic treatment and analytical solutions for surges and bores in rectangular channels (research study) **Team:** S.K. Singh DOS: April 2014 DOC: March 2015	Dr. S. K. Singh informed that the study is complete and the report will be submitted by this month.
8.	Status Report on “Impact of Anthropogenic and Climate Change on Sediment Load of Rivers” **Team:** Archana Sarkar	Mrs Archana Sarkar presented some of the findings of various research workers in the subject area. Working group members noted the progress of the study and appreciated the work.

	DOS: April 2014 DOC: March 2015	
9.	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State **Team:** Archana Sarkar, N.K. Bhatnagar, Vaibhav Garg and Rakesh Kumar DOS: April 2014 DOC: March 2016	Mrs Archana Sarkar presented the progress of the study with results of trend analysis of historical rainfall data (annual, seasonal and monthly) by parametric and non-parametric methods for four rainfall stations two each in Kumoan and Garhwal regions. Mrs Sarkar informed to include the data comparison work through hydrological modeling and requested for an extension of the study by another six months, i.e., a new time frame of April 2014 to Sept 2017. Working group members agreed for the extension.
10.	Monitoring and modelling of streamflow for the Gangotri Glacier **Team:** Manohar Arora and Rakesh Kumar DOS: May 2014 DOC: March 2017	The PI presented the future GCM scenarios of GFDL GCM. He validated the past data with observed data and explained the reason for over estimation. The future RCM output of REGCM4.3 model for the RCP8.5 scenarios were presented for 100 years. Dr Arora explained that these output will be considered while assessing the future water availability. No specific questions were asked by the experts.
11.	Effect of climate change on evaporation at point scale Team: Digambar Singh, A. R. Senthil kumar and Manohar Arora DOS: June 2014 DOC: March 2017	The PI reported that there was a slight decrease in rainfall during the considered period of analysis. There was a mild variation in temperature and humidity. The PI informed the house that high variability was observed in evaporation in the month of January from the analysis of recorded data. Highest value of the evaporation was observed in the month of May.
	NEW STUDIES	
12.	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in Chhattisgarh Dr. R.P. Pandey Dr. Rakesh Kumar DOS: April 2015 DOC: March 2017)	Dr R.P. Pandey presented a new study to be carried out in the Seonath basin in Chattisgarh state of India. The Director NIH and the Chairman Working Group suggested taking up a study in Bundelkhand region to study the possible impact of proposed Ken-Betwa interlinking project. He suggested to propose a project proposal on the above in the next working group meeting.
13.	Flood and Sediment studies in Himalayan basin using MIKE-11	Dr. A. K. Lohani mentioned that the flood study is required to be carried out in the Himalayan basins so as to simulate the impact of flooding due to cloud burst.

	Model Dr. A.K. Lohani DOS: April 2015 DOC: March 2018	Furthermore, the Himalayan rivers carry very sedimentation load and therefore, scientific study of river sedimentation is also required to be carry out.
14.	Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin Team: Dr Achana Sarkar Er. T. Thomas Dr. Vaibhav Garg DOS: April 2015 DOC: March 2018	Mrs. Archana Sarkar informed that the Institute has already carried out related studies for the Ganges basins mostly in the Garhwal Himalayas but the proposed study would be the first one for the Kumaon Himalayan River basin. Various scenarios of precipitation and temperature would be considered to study the impact of climate change on the hydrological regime of the study basin using GCM outputs.
15.	Generalization and parameter estimation of GEV distribution for flood analysis Dr. S. K. Singh DOS: April 2015 DOC: March 2016	Dr. S. K. Singh presented the study highlighting the intended objectives of the study. The GEV distribution as is widely used has two different forms (Type 2 and Type 3) as used in flood frequency analysis. It is intended to possibly unify both type 2 and type 3 GEV distributions in a single GEV and suggest both a simple and optimization method for estimation of its parameters with illustration on measured/ published data. This was well received during the discussion and no suggestions were received from the members at this stage.
16.	Analytical Solution for meeting of two surges or bores Dr. S. K. Singh DOS: April 2015 DOC: March 2016	Dr. S. K. Singh presented the study highlighting the intended objectives of the study as developing analytical equations/solutions in case two surges or bores in rectangular channel intersection from opposite direction, avoiding the currently used iterative solution, with a systematic treatment of surges. An abrupt change in discharge or depth of flow causes a surge or bore in channels. This abrupt change may be due to a sudden opening or closure of gate, part-blockage of a channel due to landslide or tidal effect. This was well received with discussion and no suggestion from the members at this stage.

SURFACE WATER HYDROLOGY DIVISION
WORK PROGRAM FOR 2015-16

S.N.	Code	Study	Study Team	Duration
	Ongoing Internal Studies			
1.	SWH/2015/ TS-1	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 Sept. 2015)
2.	SWH/2015/ TS-2	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 Sept. 2015)
3.	SWH/2015/ TS-3	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State	Archana Sarkar Vaibhav Garg, IIRS Rakesh Kumar N.K. Bhatnagar	2 years (April 2014 to Sept. 2017)
4.	SWH/2015/ TS-4	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3 Years (April 2013 to March 2016)
5.	SWH/2015/ TS-5	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills.	Avinash Agarwal Manohar Arora RK Nema	3 Years (Nov 2013 to Oct 2016)
6.	SWH/2015/ TS-6	Effect of climate change on evaporation at point scale	Digambar Singh A. R. Senthil kumar Manohar Arora	3years (June 2014 to March 2017)
7.	SWH/2015/ TS-7	Hydrological modelling, water availability analysis	J.P.Patra Rakesh Kumar Pankaj Mani	3years (April 2014 to March 2017)
	Ongoing Sponsored Projects			
1.	SWH/2015/ SR-1	Modeling of Gangotri Glacier melt runoff and simulation of stream flow variation under different climate scenarios	Manohar Arora Rakesh Kumar	3years (May 2014 to March 2017)
	New Internal Studies			
1.	SWH/2015/ TS-8	Flood and Sediment studies in Himalayan basin using MIKE-11 Model	A.K. Lohani	3 years (April 2015 to March 2018)
2.	SWH/2015/ TS-9	Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin	Archana Sarkar T. Thomas Vaibhav Garg	3 years (April 2015 to March 2018)
3.	SWH/2015/ TS-10	Study on effect of climate change on sediment yield to Pong reservoir	A. R. Senthil Kumar J. V. Tyagi Avinash Agarwal Suhas	3 years (April 2015 to March 2018)

			Khobragade Manohar Arora	
4.	SWH/2015/ TS-11	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in Chhattisgarh	R.P. Pandey Rakesh Kumar	2 years (April 2015 to March 2017)

WATER RESOURCES SYSTEM DIVISION

Dr. Sharad K Jain, Sc. G and Head (WRS Div.), presented an overview of the division – scientific strength, the ongoing studies, sponsored & consultancy studies, technical publications and training courses organized. Following are the comments received from working group on the presentations of the various studies.

PI: Dr. M. K. Goel, Scientist "F"
Study title: *NIH_Basin* – A WINDOWS based model for water resources assessment in a river basin (Ongoing)

Dr. M. K. Goel (MKG) presented the progress of the study. He informed that envisaged objectives of the study included modifications in the modeling methodology and development of WINDOWS interface named as **NIH_Basin** (**NIH_Basin Simulation**) of the model. MKG informed that, a number of modifications have been made in the model methodology and the source code for making it more practicable and realistic. Some of these include:

a) Number of land use classes has been increased from 6 to 51 for more detailed representation.
b) As suggested in last WG by Dr. Deshpande, option has been included to consider industrial demands separately and the same has been linked to city attributes.
c) Date of commissioning of hydraulic structures has been included and in the long-term simulation, their effects are considered only after their commissioning.
d) Variable GW development is now considered (it was constant initially).
e) Baseflow computation now depends on the actual GW storage in upstream basin above a gauging site.
f) Rather than considering constant human and cattle population, population growth is considered as per defined rate. For long-term simulation, revised population is estimated at the beginning of each year.
g) In the command area of hydraulic structures, which are commissioned in intermediate stages during simulation, option has been included for considering the revised cropping pattern while computing irrigation demands.

Since these modifications required changes in the input data, it was decided to first complete the model modifications and then develop the WINDOWS based forms for database preparation. The program development is nearing completion but interface development needs considerable time. MKG requested to increase the study period by 6 months which was agreed by the WG.

PI: Dr. Sanjay K. Jain (SJ), Scientist "F"

1. Glacier change and glacier runoff variation in the upper Satluj river basin (Ongoing)

Dr. Jain presented the objectives as well as the progress made so far. Three sub basins of Upper Satluj basin have been taken for this study. Dr. Jain presented the analysis of temperature and snow water equivalent data and explained correlation between these with glacier change. SJ informed that the data base preparation for snowmelt runoff modelling is under progress and presented the results of snow cover depletion. Dr. Deshpande asked whether snow and glacier mapping vis-à-vis aspect can be carried out. He also suggested that analysis related to trend in a time series may be carried out at different time step, say a decade instead of taking long-term linear trend. Dr. Bartarya informed that some of glacier studies in Baspa basin have been carried out which can also be reviewed. These suggestions were noted.

2. Modelling of Narmada Basin using GWAVA Model (Ongoing)

SJ presented the status as well as the progress. He informed that entire Narmada basin will be considered in the present study, however, initial calibration will be carried out up to Hoshangabad in which three important storage structures are Bargi, Barna and Tawa reservoirs. Dr. Jain also informed about different processes and components of GWAVA model. A training workshop on the GWAVA model was conducted by experts from Centre of Ecology and Hydrology (CEH), United Kingdom during 02-05 March, 2015. Dr. Jain also presented different thematic maps/ model inputs prepared so far. Dr. Sharad Jain suggested inclusion of Madhya Pradesh Council of Science and Technology in the study. Dr. Deshpande suggested inclusion of tectonic features (differential pathways) in the model. Dr. Jain replied that if such feature is available in the GWAVA model, the same will be tried.

PI: D. S. Rathore (DSR), Scientist "F"

1. Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra (Ongoing)

The progress of the study was presented by DSR. For multi reservoir operation application, Khadakwasla reservoir complex was chosen. The complex has four reservoirs namely Khadakwasla, Temghar, Warasgaon and Panshet. Uptake of water for urban supply to Pune city and Mutha RBC is done from Khadakwasla reservoir. Hydro power generation is also done in Warasgaon and Pashet reservoirs. Simulations were done for FRL and 75% dependable reservoir water levels for varying demands. For 6% increased demands, reliability of supply reduced up to 86% and 73% for town and irrigation demands respectively. Probability of drought magnitude (SPI based) was estimated for monthly rainfall data. The probability varies from 40 to 70% for magnitude greater than one. Water quality model setup was elaborated. Availability of data for various pollutant sources, person-load were presented. Pollutant load temporal distribution was conceptualized as runoff based or uniform. Dr Deshpande inquired about differences in reliability of water supply to different users for a scenario. DSR informed that difference is due to different priority assigned to the users. Water allocation in any time step is based on priority. Water supply reliability will be higher for higher priority user. In this case, urban user is given first priority and irrigation user is assigned 2nd priority. Chairman pointed out that in reliability table, demand should also be written for clarity.

2. Web GIS based snow cover information system for Indus basin (Completed)

In the study, snow cover mapping for Indus basin was completed for year 2007 to 2012 using MODIS data. NDSI and NIR bands were used from 8-day composite MOD09A1. FCC were visually inspected to identify cloud cover and for scenes with significant cloud cover, snow area of cloud free preceding and/or succeeding dates were used in snow statistics. Snow cover raster maps were processed to obtain snow polygons. The polygons were used in Geoserver based web application. Sub basin wise yearly variation in snow cover area during 1st September to 31st August was studied. There was significant snowfall in eastern part of Indus basins during September- November in many years. Visualization in web browser for snow cover maps in different days was demonstrated. Mr Kishor Kumar inquired about extending the application to other basins. Further, since web pages are created dynamically, i.e. server data being accessed by the application on user request, the security audit of the application will be needed. The audit may be done by empanelled agencies. It was informed that for extending the application to other basin, snow maps need to be generated from MODIS data and published in Geoserver. Further, links in HTML application need to be updated. Application is currently deployed on intranet. Dr. Sanjay Jain informed that security audit will be initiated prior to deploying the application on web.

PI: Deepa Chalisgaonkar (DC), Scientist "F"

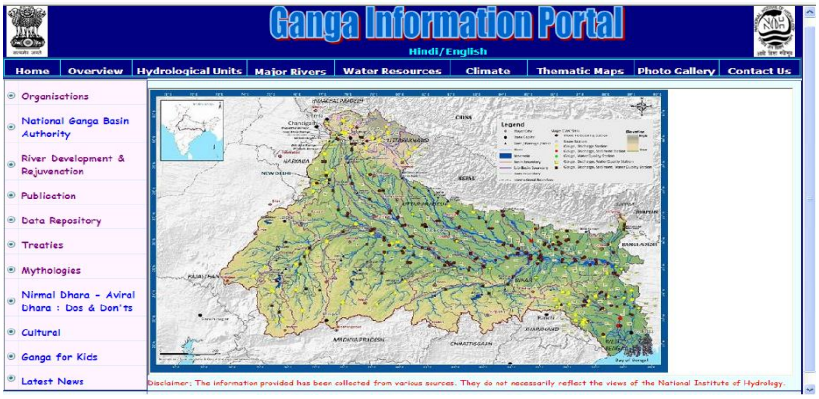
1. Assessment of Water Footprint of the National Capital Territory (NCT) of India (Completed)

DC informed that the objective of this study is to estimate the water footprints of NCT Delhi from both a supply and consumption perspective 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. The methodology used in this study is largely based on earlier studies supported by Water Footprint Network (www.waterfootprint.org) and the three components of water footprint have been computed for domestic, agriculture and industrial sector 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 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. Missing data has been assumed. 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) has been taken for the computation of dilution water requirement. For the computation of crop water requirement, CROPWAT software has been used and for the grey water component only the nitrogen fertilizer use has been incorporated. This means only the most critical pollutant with the greatest application rate is being considered. Virtual water import component has also being considered for the computation of agriculture water footprint as lot of agriculture related products are brought in Delhi for consumption. WG noted the progress of the study.

2. Development of Ganga Information Portal

DC presented the proposed new study on development of Ganga Information Portal,

which is envisaged to provide a unique platform comprising multisource data and information on Ganga basin. The major objective is to develop a knowledge/ information e-portal with exhaustive information on Ganga basin. Govt. of India is keen to clean rivers of India, beginning with Ganga and restore 'Nirmal dhara' and 'Aviral dhara'. Recognizing the multi-sectoral, multi-dimensional and multi-stakeholder nature of information in the Ganga basin, the need is to develop a web-based platform where different types of data/ information (facts; publications; data; maps; photographs; etc.) related to Ganga basin is available at one place. 'Ganga Information Portal' (GIP) is a step in this direction. DC also presented the proposed framework of the portal.



PI: Dr. Renoj J Thayyen (RJT), Scientist "D"

1. Glaciological studies of Phuche Glacier, Ladakh Range (Ongoing-Sponsored)

Main objective of this project is to evaluate the winter and summer mass balance of the Phuche glacier. RJT informed that the Phuche glacier experienced negative mass balance during 2013-2014 mass balance year. Progress made on analysing the energy balance data to achieve the mass balance modelling was also presented. No specific suggestions were received.

2. Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range (Ongoing)

This project is aimed to evaluate the catchment scale hydrologic processes of the cold-arid regime. RJT informed about the establishment of a new discharge station at Gonpa near Leh to monitor round the clock discharge of the perennial stretch of the stream. Studies on permafrost thaw in the catchment continued during the reporting period. Electrical conductivity and discharge showed clear inverse relationship between the two during the peak discharge month of July and August which changed to in phase relationship in the month of September suggesting ground ice melt contribution. There were no specific suggestions/ comments from any member.

3. Runoff modeling of Shyok River, Karakorum Range (New)

This project is executed in coordination with border Roads Organisation (BRO) at km 150 of Durbuk—DBO axis. The project was initiated in January 2015. RJT informed

that the Radar Water Level Recorder has been already installed to monitor the water level at km 150. It has been a challenging task to raise a cantilever structure with a 10m long arm. RJT informed that steps for procurement of AWS will be initiated soon. No specific suggestions were received for this project.

PI: Shri L N Thakural (LNT), Scientist "B"

1. Trend and variability analysis of Rainfall and Temperature in Himalayan region (Completed)

The objectives of the study were 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 were applied to determine the trends in the time series data of these meteorological variables. The trend analysis on seasonal and annual scale carried out for the rainfall using APHRODITE data during the last quarter along with overall results for the entire Himalayan region were presented in the meeting. No specific suggestions were received for this project.

2. Study of Hydrological Changes in selected watersheds in view of Climate Change in India (New)

PI of the study (LNT) presented the background, objectives, methodology and the expected deliverables of the new studyand informed that this 3 years (2015 to 2018) project will be executed through internal funds. It was informed that probable climate change and its perilous impact on the hydrologic system poses a threat to global fresh water resources and aquatic ecosystems worldwide. These changes are not uniform and vary from place to place or region to region. Thus, the present study intend to assess the hydrological changes in watersheds located in different parts of India under changing environment for proper planning and management of water resources. It was also informed that four watersheds will be selected from four different climatic regions of India mainly depending upon the data availability, easy accessibility and having different usage classes (Land use/Land cover). It was decided that one watershed will be studied in association with CWRDM, Kerala, under the MOU signed between NIH and CWRDM.

PI: Shri P. K. Mishra (PKM), Scientist "B"

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

PKM presented the progress made in the study since inception as well as during last six months (November '14-March '15). PKM presented the objective-wise progress made in the study. Shri Mishra presented the future rainfall and temperature downscaled from HadCM3 A2 and HadCM3 B2 GCM data utilizing SDSM model for the KBK region. The study has been carried out using SDSM tool version 4.2.9. Further, to assess the water availability and utilization, input data for two basins viz. Tel basin (sub-basin to Mahanadi basin) and Sarbari basin (sub-basin to Godavari basin) is under preparation to run Soil and Water Assessment Tool (SWAT) model. Mr. Mishra requested to extend the study by 12 months which was agreed by the WG.

PI: Shri M. K. Nema (MKN), Scientist "B"

1. Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj (Ongoing)

The progress of the study was presented by MKN. During the presentation no specific comments were made by any member. However, Dr. Rangarajan Ramaswamy, Chief Scientist, NGRI suggested to modify the tabular representation of groundwater data. Suggestion shall be followed in the future presentations.

2. Hydrological Processes and Characterization of Lesser Himalayan Catchments

MKN presented the progress of the study, which is experimental in nature and requires setting up instruments in the proposed watersheds. Dr. Sharad K Jain, Sc 'G' & Head WRSD, suggested that the stream gauging structure be constructed before the monsoon so that the flow data of the monsoon season can be collected. Mr. Nema replied that initiatives have already been taken to implement the gauging structure before monsoon.

PI: Shri P. K. Agarwal, Scientist "B"

Study title: Hydrologic Modelling of a part of Satluj Basin using SWAT Model (Ongoing)

The progress of the study was presented by Shri Tanvear Ahmad, Scientist B & Co-PI. He informed that SRTM DEM has been downloaded and the study area and drainage network have been generated with the help of the same. Preparation of land use map & Soil map are nearing completion. Some meteorological data has been collected. Database preparation for running SWAT is under progress. No specific comments were received.

WATER RESOURCES SYSTEMS DIVISION
WORK PROGRAM FOR 2015-2016

SN	Code	Study	Study Team	Duration
	Ongoing Internal Studies			
1.	WRS/2015/TS-1	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Deepa Chalisgaonkar Sharad K. Jain Prabhash K. Mishra	3 Years (04/13-03/16)
2.	WRS/2015/TS-2	Assessing climate change impact across KBK region of Odisha	P. K. Mishra Sharad K. Jain Sanjay K. Jain	3 Years (04/13-03/16)
3.	WRS/2015/TS-3	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)
4.	WRS/2015/TS-4	Variability of the Hydro-climatic variables in Punjab Plains of Lower Satluj	M. K. Nema Sharad K. Jain	2 Years (11/13-10/15)
5.	WRS/2015/TS-5	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)
6.	WRS/2015/TS-6	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain M. K. Goel Sanjay K. Jain M. K. Nema Tanvear Ahmed	2 -3/4 Years (06/14-3/17)
7.	WRS/2015/TS-7	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)
8.	WRS/2015/TS-8	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. K. Nema	2.25 years Dec. 2014 – Mar 2017
9.	WRS/2015/TS-9	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years Dec-2014 to Nov-2017
10.	WRS/2015/TS-10	Hydrological process and characterization of Lesser Himalayan Catchments	M. K. Nema Sharad K. Jain Sanjay K. Jain Renoj J.Thayyen P. K. Mishra P. K. Agarwal	5 Years 12/14-12/19
	Ongoing Sponsored Studies			
1.	WRS/2015/SR-1	Glaciological studies of Phuche Glacier, Ladakh Range, India (DST)	Renoj J. Thayyen M K Goel S P Rai	5 Years 1/10-06/15

2.	WRS/2015/SR-2	Assessment of Environmental flow for Himalayan River (MOES)	Sharad K. Jain Pradeep Kumar P. K. Agarwal P. K. Mishra	1 Year 07/14-07/15
	New Internal Studies			
1.	WRS/2015/TS-11	Development of Ganga Information Portal	Deepa Chalisgaonkar Sharad K. Jain D. S. Rathore Sanjay K. Jain Sudhir Kumar P. K. Mishra P. K. Agarwal M. K. Nema Furquan Ullah	3 years (04/15-03/18)
2.	WRS/2015/TS-12	Study of Hydrological Changes in selected watersheds in view of Climate Change in India	L. N. Thakural D. S. Rathore Surjeet Singh Tanvear Ahmed Sanjay K. Jain Sharad K. Jain	3 years (04/15-03/18)

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)

SN	Title of Project/Study, Study Team	Status and Recommendations/Suggestions
1.	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	The study was presented by Dr. V.C. Goyal (PI). There were no any comments in this study.
2.	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	The study was presented by Dr. R.V. Kale (PI). There is no any specific comment. However, Mrs. S. Kaur, IMD opinioned that it should have better option when application of WEAP model may have carried out initially for a gauged basin.
3.	Water conservation and management in Ibrahimpur Masahi village of Hardwar district (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, and Rajesh Singh DOS: Apr 2013, DOC: March 2015	The study was presented by Er. Omkar Singh (PI). The PI requested for one year extension to perform relevant tasks of this study and WG agreed. However, the Chairman suggested to utilize the boat facility for bathymetric survey of ponds in the villages. The PI noted the suggestions for compliance.
4.	WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** V C Goyal (PBS Leader), Jyoti Patil and R V Kale **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna) DOS: Apr 2015, DOC: Mar 2016 (**New study)**	The study was presented by Dr. Jyoti Patil. There is no any specific comment. However, the duration of this study may be increased from 1 year to 2 years.

RESEARCH MANAGEMENT AND OUTREACH DIVISION
WORK PROGRAM FOR 2015-2016

SN	Code	Title of Project/Study, Study Team	Duration
	Ongoing Internal Study		
1.	RMO/2015/TS-1	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
2.	RMO/2015/TS-2	Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, and Rajesh Singh	DOS: Apr 2013 DOC: March 2016
	New Internal Study		
3.	RMO/2015/TS-3	WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** V C Goyal (PBS Leader), Jyoti Patil and R V Kale **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna)	DOS: Apr 2015 DOC: Mar 2017
	Sponsored Project		
1.	RMO/2015/SR-1	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 (**Ongoing study)**

Proposed Technical Transfer & Outreach Activities during 2015-2016

SN	Code	Activity
1	RMO/2015/OR-1	Outreach activities (IITF-2015, IWW, other exhibitions)
2	RMO/2015/TW-1	5-day Workshop on “Citizen science in hydrology and water resources”
3	RMO/2015/TW-2	Orientation training of newly appointed scientists
4	RMO/2015/OR-2	Science-Policy interface, IPR issues, and technical meetings
5	RMO/2015/OR-3	Establishment of “Water Activity Centre”
6	RMO/2015/LCU	Operational expenses of LCU-Delhi

Dr. V C Goyal 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 who attended the 42nd WG meeting

1.	Er. R.D. Singh, Director, NIH	Chairman
2.	Dr. S.K. Bartarya, WIHG, Dehradun	Member
3.	Dr. (Mrs.) Surinder Kaur, DDGM(H), IMD, New Delhi	Member
4.	Dr. S C R Vishvakarma, Sc.F, GBPIHED, Almora	Member
5.	Dr. R D Deshpande, Sc.SF, PRL, Ahmedabad	Member
6.	Dr. R.Rangarajan, Sc.G, CSIR-NGRI, Hyderabad	Member
7.	Dr. N.B. Narasimha Prasad, Ex. Director, CWRDM. Kozhikode	Member
8.	Dr. Kishore Kumar, Sr. Tech. Director, NIC, New Delhi	Member
9.	Dr. S.K. Jain, Sc. G & Head WRS Division, NIH	Member
10.	Dr. Rakesh Kumar, Sc. G & Head SWH Division, NIH	Member
11.	Dr. Sudhir Kumar, Sc. G & Head HI Division, NIH	Member
12.	Dr. V C Goyal, Sc. F & Head, RMO Division, NIH	Member-Secretary

Scientists from National Institute of Hydrology, Roorkee

	EH Division		**SWH Division**
1	Dr. R.D. Mehta, Sc.D	18	Dr. J.V. Tyagi, Sc.G
2	Dr. M.K. Sharma, Sc.D	19	Dr. Avinash Agarwal, Sc.F
3	Dr. Rajesh Singh, Sc.B	20	Dr. S.K. Singh, Sc.F
	GWH Division	21	Dr. R.P. Pandey, Sc.F
4	Er. C.P. Kumar, Sc.F	22	Dr. A.K. Lohani, Sc.F
5	Dr. Anupama Sharma, Sc.D	23	Dr.A R Senthil Kumar, Sc.D
6	Dr. Surjeet Singh, Sc.D	24	Dr. Sanjay Kumar, Sc.D
7	Sh.Rajan Vatsa, Sc.B	25	Dr (Mrs) Archana Sarkar, Sc.D
8	Sh. Sumant Kumar, Sc.B	26	Dr. Manohar Arora, Sc.D
9	Mrs. Shashi Poonam, Sc.B	27	Sh. Digamber Singh, Sc.B
	HI Division	28	Sh. J.P. Patra, Sc.B
10	Dr.Suhas Khobragade, Sc.E		**WRS Division**
11	Dr. S.P. Rai, Sc.D	29	Smt. D.Chalosgaonkar, Sc.F
12	Dr. M.S. Rao, Sc.D	30	Dr. Sanjay Jain, Sc.F
13	Sh. S.K. Verma, Sc.D	31	Dr. M.K. Goel, Sc.F
14	Sh. P.K. Garg, Sc.B	32	Er. D. S. Rathore, Sc. F
	RMO Division	33	Dr. Renoj J. Thayyen, Sc.D
15	Er. Omkar Singh, Sc.E	34	Sh. L.N. Thakural, Sc.B
16	Dr. Ravindra Vitthal Kale, Sc.B	35	Sh. Manish Nema, Sc.B
17	Dr (Mrs) Jyoti P. Patil, Sc.B	36	Sh. P.K. Mishra, Sc.B
		37	Sh. Tanveer Ahmad, Sc.B
		38	Sh. P.K. Agrawal, Sc.B

Progress of Work Programme for the Year 2015-16

S.No.	Study	Study Team	Duration
	Internal Studies		
1.	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) C. K. Jain Anju Choudhary	2 Years (05/14-05/16)
2.	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)
	Internal Studies (New)		
3.	Status Report on Phytoremediation of Wastewater	Rajesh Singh (PI) C. K. Jain	6 Months (11/15 – 04/16)
	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 Shyam Lal	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) Extended for 3 months. Sponsored by: UNICEF, U.P. Amount: 12 Lacs (Completed)
2.	Petroleum Product Contamination at Akolner Village, District Ahmednagar, Maharashtra and Suggesting Remedial Measures	C. K. Jain Sudhir Kumar M. K. Sharma Rajesh Singh	One Year (10/15-09/16) Sponsored by MPCB Amount 54.72 lacs
3.	Assessment of Ground Water Contamination due to Past storage of Spent wash in Kachacha Lagoons and Suggesting Remedial Measures	C. K. Jain Sudhir Kumar M. K. Sharma Rajesh Singh	3 Months (11/15-01/16) Sponsored by Saraya Distillery, Gorakhpur Amount 5.7 lacs

Training Course to be Organized

S.No.	Topic	Sponsored by	Venue	Period
1.	Hands on Advanced Instruments of Water Quality Testing	MoWR, RD & GR, New Delhi	NIH, Roorkee	11-15 Jan. 2016

Study – 1 (Internal Study)

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: May 2016

7. Duration of the Study: Two years

8. Study Objectives:

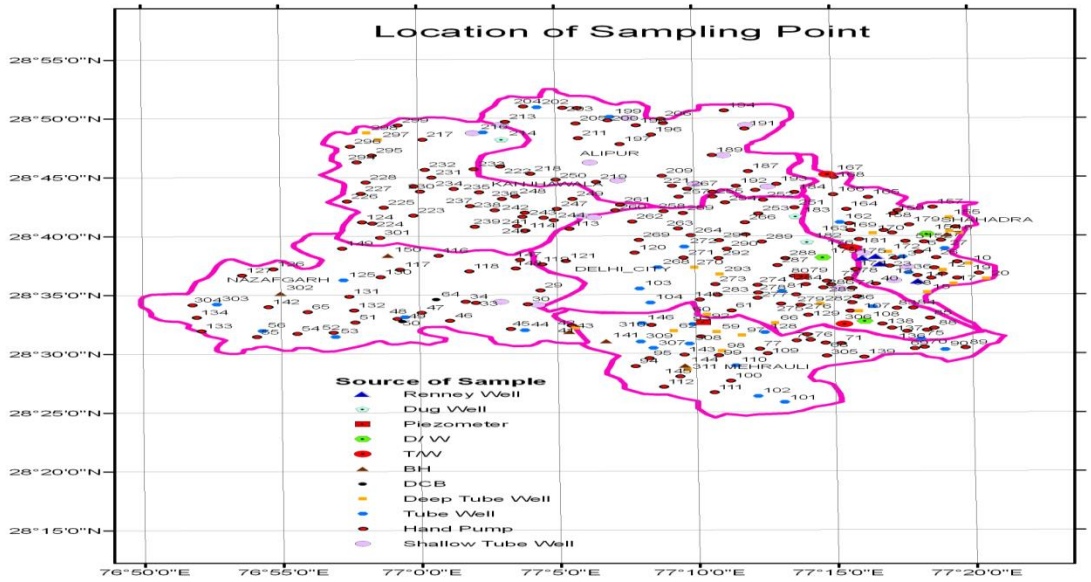
To develop the models for assessment of the quality of water with its quality parameters for Najafgarh, Mehrauli, Delhi City and Shahdara blocks of NCR using conventional and soft computing techniques.

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 Shahdara. The ground water sampling locations have been depicted as below (Fig. 1):



Water quality Modeling for two administrative blocks viz. Delhi City & Shahdara have been done with three different techniques and results have been analyzed with empirical techniques for Water Quality Index during last year. Water quality Modeling for Mehrauli administrative block has been done this year. Data analysis and modeling for another block Najafgarh is in progress.

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 Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.	4th Qr.
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
i) Model Development with application of soft computing methods. ii) Data analysis for another block as Najafgarh. iii) Model development for block Najafgarh.	i) Three models (Each model with Empirical method, CCME_WQIG and Fuzzy Inference Technique) have been developed for Mehrauli block. ii) Data analysis for block Najafgarh is in progress. iii) Model development for block Najafgarh is under progress.
Testing, Evaluation and comparison with conventional method.	Results via Fuzzy model have been compared with conventional method and Canadian formula (CCME) for Mehrauli 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 Mehrauli 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 Mehrauli with new emerging techniques to get the Water Quality Index for specific use of ground water	Completed for Mehrauli block
Solution of identified problem	Completed for Mehrauli 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 can be developed for another administrative block of NCR as Najafgarh using same techniques.

Study -2 (Internal Study)

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 Shri Rakesh Goyal, Tech. Gr. I Shri Dayanand, Tech. Gr. II

3. **Type of Study:** Internal

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

5. **Date of start:** 01.07.2014

6. **Scheduled date of completion:** 30.06.2017

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 & Analysis	• Samples were collected in month of June and November 2015. • Analysis is under progress.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
i) Dr. S.K. Bartarya, WIHG,	Analysis of silica in the samples

	Dehradun suggested analysis of silica and plot Na+K conc. Vs Silica concn. for silicate weathering.	started.
ii)	Director NIH suggested correlating the water quality parameters with flow.	CWC officials informed that the flow data is classified in nature.

14. Analysis & Results:

- Samples collected in month of June and November 2015.
- Physico-chemical and bacteriological analysis of collected samples completed and isotopic (δO^{18} & δD) analysis is under progress.

15. End Users / Beneficiaries of the study: State Govt. Planners

16. Deliverables: Technical report & 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: -

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 (Sponsored Project)

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 Sri Shyam Lal, JRF

3. **Type of Study:** Sponsored project by DST, New Delhi, **Budget: Rs 32.80 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 meltwater.
   ii) Chemical characterization of the suspended sediment of Gangotri glacial system
   iii) To study Ionic enrichment dynamics of meltwater-glacial sediment interaction
   iv) To investigate open and closed system low temperature ionic enrichment process

9. **Statement of 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 Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.	4th Qr.
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
Collection of SS and meltwater samples	Meltwater and suspended sediment samples were collected from Gomukh, Bhojwasa and Gangotri from 10 May to 10 October 2015.
Chemical analysis of SS and meltwater samples	• Insitu parameters like Air Temperature, Water Temperature, pH, EC and bicarbonate were measured. Chemical analysis of meltwater sample is under progress.

13. Recommendation / Suggestion: None

Recommendation / Suggestion	Action Taken
None	None

14. Analysis & Results:

a) Meltwater and suspended sediment samples from Gomukh, Bhojwasa and Gangotri were collected during 10th May to 10th October 2015.

i) Air Temperature, Water Temperature, pH, EC and bicarbonate were measured at the time of sampling.

ii) Chemical analysis of collected meltwater sample is under progress.

iii) Processing of hydro-chemical data 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) 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:

- Dissolution experiments of glacial meltwater-suspended sediment interaction
- Geochemical analysis of suspended sediment
- Processing of hydro-chemical data.

Study -4 (New Internal Study)

1. Thrust Area under XII Five Year Plan: Environmental Hydrology

2. Project Team:

a. Project Investigator: Dr. Rajesh Singh, Sc. C, EHD
b. Project Co-investigator: Dr. C. K. Jain, Sc. G, EHD

3. Title of the Project: Status Report on Phytoremediation of Wastewater

4. Objectives:

- Status report on phytoremediation of wastewater

5. Present state-of-art:

Increasing urbanization, industrialization and over population is one of the leading causes of environmental degradation and pollution. Water bodies are the main and the final destination for capturing these pollutants. They receive industrial waste, residential waste, surface runoff etc. and causing serious effects on humans, animals and plants. Therefore, waste water treatment is essential for health, aesthetic, ecological and other purposes which has become a serious problem. Coagulation, precipitation, ion exchange, reverse osmosis, electrolysis, and bacteriological degradation are the most usable treatments in practice for sanitation of water and removal of these contaminants. The majorities of these methods in practice consumes huge economic resources and are producing lots non-eco-friendly wastes as well as highly power consuming. Aquatic plant based treatment options (phytoremediation) are cost effective when the treated water has to be used for tertiary applications and can be adopted by developing countries. The word phytoremediation comes from Greek word *phyto* which means plant and Latin word *remediation* which means to remove, which refers to a diverse collection of plants based technologies that use either naturally occurring, or genetically engineered plants to clean contaminants. It is a clean, efficient, inexpensive and environment friendly technology. It is a non-invasive alternative technology for engineering-based remediation methods. The primary motivation behind the development of phytoremediation technologies is the potential for low-cost remediation. The plants used in the treatment scheme are known as pollution mitigators.

Various researches employing the process of phytoremediation had been carried out for the remediation of contaminated water, both domestic and industrial wastewater ranging from the use of micro organisms, shrubs to trees (Shumate and Strandberg, 1985; Guntensbergen, 1989; Breen, 1990; Rogers et al., 1991; Andres et al., 1992; Fourest and Roux, 1992; Burken and Schnoor, 1997; Twilley, 1998; Ewel et al., 1998; Mcfarlane and Burchett, 1999; Hussein et al., 2003; Hussein et al., 2004).

This study will lead to development of a document related to phytoremediation techniques based on the published data on research carried out in this aspect. It will

provide a glimpse of various kinds of scientific work that has been carried out on phytoremediation technique and suggest areas and problems that need to be addressed in the future.

6. Methodology:

a. Literature Survey
b. Processing of literature survey into status report on phytoremediation.

7. Research Outcome from the Project:

a. Technical report and paper

8. Cost Estimate:

a. Total cost of the project : Rs. 50 000.00
b. Source of funding : NIH (Internal)
c. Sub headwise abstract of the cost :

Sr. No.	Sub-Head	I Year
1	Salary for JRF/SRF	00
2	Travelling expenditure	00
3	Infrastructure / Equipment / Consumable	10 000
4	Experimental charges	00
5	Misc. Expenditure	40 000
	Grand Total	50 000

d. Justification for sub-head-wise abstract of the cost:

- Consumables: Purchase of stationary, printer cartridges, etc.
- Miscellaneous Expenditure: Towards purchase of books, xerox, etc.

9. Work Schedule

a. Probable date of commencement of the project: November 2015
b. Duration of the project: 6 months
c. Stages of work & milestone

S. No.	Major Activities	2015-16	
		3rd Qtr.	4th Qtr.
1	Literature Survey		
2	Status Report		

WORK PROGRAMME FOR THE YEAR 2015-16

S. No.	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/NIH/ 15-18	Development of Website and e-Portal on "Mitigation and Remedy of Arsenic Menace in India"	C.P. Kumar (PI), Anupma Sharma, Suman Gurjar, Sanjay Mittal	3 years (04/15 – 3/18) **Status**: **In progress**.	Internal Funding.
2. NIH/GWD/NIH/ 14-17	Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin	Anupma Sharma (PI) N. C. Ghosh Groundwater Hydrology Division in association with Prof. Deepak Kashyap, IIT Roorkee, as Technical Consultant	3 years (December, 2014 – Nov., 2017) Status: **In progress**.	Internal Funding.
3. NIH/GWD/NIH/ 15-16	Alternate water supply management strategies in arsenic affected/ vulnerable areas: Mapping of Arsenic affected zones/regions in Eastern U.P	Sumant Kumar (PI) N.C. Ghosh, Rajesh Singh, R.P. Singh, Suman Gurjar, S.L. Srivastava, Anju Choudhary	1 year (04/15 – 3/16) **Status: In progress.**	Internal Funding.
Proposed New Study				
4 NIH/GWD/NIH/ 15-18	**Peya Jal Suraksha -** Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply.	N.C. Ghosh (Project Coord. & Leader) C.P. Kumar, B. Chakraborty, Y.R.S. Rao, Anupma Sharma, Surjeet Singh, Sumant Kumar, Suman Gurjar, S.P. Indwar, R.P. Singh, Anju Choudhury, Sanjy Mittal, Ram Chandar, Staff SW Lab	21/2 year (11/15 – 4/18) **Status: New.**	Sponsored by MoWR, RD & GR under Plan Fund.
5. NIH/GWD/NIH/ 15-16	Web Enabled "Groundwater Recharge Estimation Model (WE-GREM) ".	Suman Gurjar (PI), N.C. Ghosh, Sumant Kumar, Surjeet Singh, Anupma Sharma	1 year (08/15 – 3/16) **Status: New.**	Internal Funding.
6. NIH/GWD/NIH/ 16-17	Groundwater fluctuations and conductivity monitoring in Punjab.	Gopal Krishan (PI), N.C. Ghosh, Surjeet Singh, Dan Lapworth (PI from UK) Alan MacDonald (Project Coordinator)	1 year (01/16 – 12/17) **Status: New.**	Sponsored by BGS, UK.

The detailed status of the studies is given in Annexure-I.

Staff strength and facilities available

Scientists : 7 (Dr. N. C. Ghosh, Sc-G; Mr. C. P. Kumar, Sc.-G; Dr. Anupma Sharma, Sc-D; Dr. Surjeet Singh, Sc.-D; Mr. Sumant Kumar, Sc.-C; Ms. Suman Gurjar, Sc-C; Dr. Gopal Krishan, Sc-C)

Scientific staff: 8 (SRA-3, RA-1; Tech-3; PS-1)Resource Person -1

Soil-Water Lab. **i**s functioning under the Division

Division has established the '**Centre of Excellence for Advanced Groundwater Research"** which was inaugurated by Sushri Uma Bharati, Hon'ble Union Minister for WR, RD & GR on 26th Oct., 2015**.**

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

1. Organized a one-day workshop on "*Indo-German Workshop on "Bank Filtration in India" under Indo-German Competence Centre for Riverbank Filtration*" on 28th September, 2015 at NIH, Roorkee.

2. Scientists published/accepted **10 papers** in international journals**, 3** in national journals and **10 papers** in international conferences.

3. Scientists/scientific staff delivered **20 lectures** in different training courses and Workshops.

4. One scientist of the division guided one Ph.D thesis.

1. **PROJECT REFERENCE CODE: NIH/GWD/INT/15-18**

Thrust Area under XII five year Plan: Technology Transfer and Outreach Activities

1. Project team:

a) Project Investigator — Mr. C. P. Kumar
b) Project Co-Investigator(s) — Dr. Anupma Sharma, Ms. Suman Gurjar, Mr. Sanjay Mittal

2. Title of the Project: *Development of Website and e-Portal on "Mitigation and Remedy of Arsenic Menace in India"*

3. Objectives:

- To develop website and e-Portal on "*Mitigation and Remedy of Arsenic Menace in India*".
- Information dissemination as well as gathering responses and opinions through e-Portal.

4. Present state-of-art

Presently, no website/e-Portal exists in India where information related to mitigation and remedy of arsenic menace in India is disseminated and responses and opinions are gathered.

5. Methodology

- Presentation by NIC empanelled vendors on suitable designs of website/e-Portal on "Mitigation and Remedy of Arsenic Menace in India" to finalize the requirements of website/e-Portal
- Registration of domain name (nih-arsenic.gov.in)
- Development of website and e-Portal on "Mitigation and Remedy of Arsenic Menace in India" through NICSI
- Hosting of website at NIC Headquarters, New Delhi on cloud servers
- Release of website/e-Portal and Brain Storming Session to discuss the relevant issues
- Information dissemination, gathering responses and opinions through e-Portal
- Maintaining and updating the website/e-Portal

6. Research outcome from the project

Website/e-Portal on "*Mitigation and Remedy of Arsenic Menace in India*" and responses/opinions on related issues.

7. Present Status

- Correspondence with Technical Director, NIC was made during April-May 2015 and the list of NICSI empanelled vendors was obtained.

- A proposal was submitted to Director, NIH on 29.5.2015 to obtain administrative approval for (a) registration of domain name "*nih-arsenic.gov.in*", (b) development of website through NIC/NICSI by their empanelled vendor, and (c) hosting the website at NIC.

- However, the administrative approval from Director has not been received. It appears that due to non-availability of required funds during the current financial year (2015-2016), the proposal could not be approved.

  In view of non-availability of required funds, the above study is proposed to consider as deferred will be included in the work plan of 2016-2017 if the required funds become available.

  Working Group may consider.

2. **PROJECT REFERENCE CODE: NIH/GWD/INT/14-17**

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 association with Prof. Deepak Kashyap, IIT Roorkee, as Technical Consultant

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

Date of start: December 2014

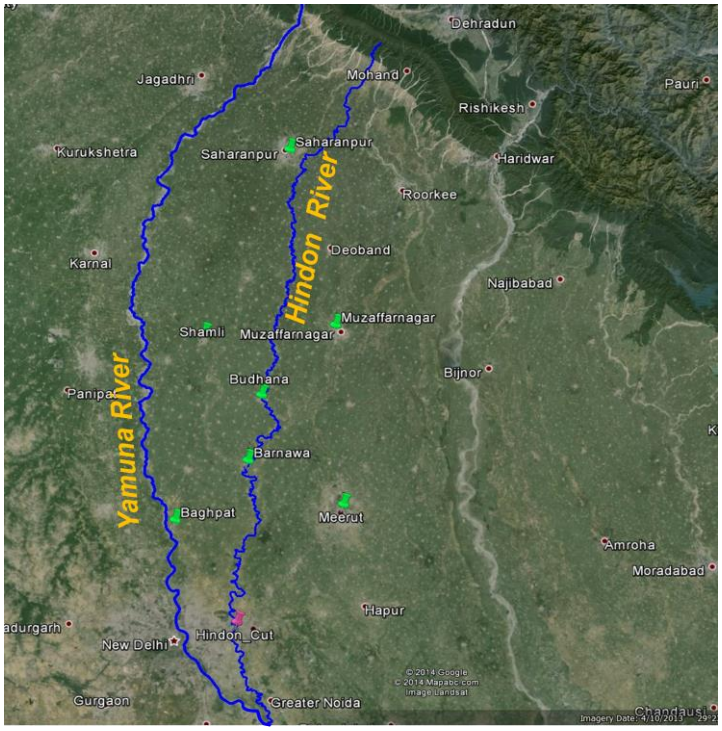
Duration of study: Three years

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 domestic and irrigation water supply in the fertile Yamuna-Hindon inter-basin. Need to develop strategies for conjunctive management of water resources in the region.

Location map:



Objectives vis-à-vis Achievements:

Objectives	Achievements/ Activities
Literature review	Completed till date
Data collection	Collection of historical data groundwater levels, river stage data, crop cultivation, irrigation schemes, relevant reports and maps, meteorological data, data collection during field visit
Field experiments and Laboratory investigations	- Soil samples collected - Soil sample analyses in laboratory for soil moisture characteristics
Database preparation	DEM, land use, soil texture, drainage, groundwater levels (pre & post monsoon), water demand
Data analysis	Analysis of water table and water quality data, satellite data, land use; Analysis of soil samples and data for infiltration and saturated hydraulic conductivity

Adopters of the results of the study and their feedback: Study yet to be completed

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

1. Reports
2. Research Papers

Lab facilities used during the study:

1. Soil and Water Lab, NIH
2. Water Quality Lab, NIH

Future plan:

1. Field surveys and data collection
2. Groundwater and surface water quality analysis to continue
3. Numerical simulations

3. PROJECT REFERENCE CODE: NIH/GWD/INT/15-16

Title of the study: Alternate water supply management strategies in arsenic affected/ vulnerable areas: Mapping of Arsenic affected zones/regions in Eastern U.P

Team members : 1) Mr. Sumant Kumar- PI
2) Dr. N.C Ghosh, Sc.-G, GWHD
3) Dr. Rajesh Singh, Sc-C, EHD
4) Dr. R.P. Singh, SRP, GWHD
5) Mrs. Suman Gurjar, Sc.-C, GWHD
6) Sri S.L. Srivastava, S.R.A, GWHD
7) Mrs. Anju Choudhary, S.R.A, GWHD

Type of study : Internal

Date of Start : 1st April, 2015

Scheduled Date of Completion : 31st March, 2016

Location Map : Study area is Ballia district in eastern U.P.

Objectives

(i) Baseline data collection & diagnosis survey of the area affected by and vulnerable to arsenic contamination.

(ii) Arsenic risk zone mapping for Ballia district.

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

Groundwater arsenic contamination in UP was first exposed in 2003 by School of Environmental Science (SOES) on survey of 25 villages in Ballia District. As of 2008, 3 districts covering 69 villages in 7 blocks in Uttar Pradesh were found affected by arsenic groundwater contamination and people suffering from arsenical skin lesions. All the arsenic affected districts in UP and 12 districts in Bihar are aligned along the linear track of river Ganga.Gangetic Alluvium is the main grological formation exposed in the study area. The Gangetic Alluvium is divided into (i) Older Alluvium of middle to late Pleistocene age and (ii) Newer Alluvium of Holocene age. The studied carried out by different agencies/researchers have one commonality that the concentration of Arsenic (As^{3+}) more than permissible limit of 50 µg/l occurs in the groundwater from Newer Alluvium of Holocene age and the groundwater occurring in the Older Alluvium. This suggests that the arsenic contamination is of geogenic nature. The proposed study focuses on mapping and zoning the arsenic concentration.

The proposed study is undertaken in light of the recommendation given by Inter-Ministerial Group (IMG) on “Arsenic Mitigation” constituted by Ministry of Water

Resources, River Development & Ganga Rejuvenation and Public Accounts Committee (PAC, eighth report, 16th Lok Sabha) on 'Water Pollution in India'. PAC recommended under Groundwater Pollution: "Alternate sustainable programmes be launched for ensuring supply of arsenic-free water through conjunctive use of surface water and in situ groundwater after thorough scientific studies". The proposed study will be a step forward in understanding the root causes and magnitude of arsenic contamination in eastern U.P. and for attaining sustainable supply of arsenic safe groundwater to affected areas.

Approved action plan

- Literature Review
- Field Investigations & Data Collection
- Sample Collection, analysis & interpretation
- Risk zone mapping

Objectives & Achievements

Baseline data collection & diagnosis survey of the area affected by and vulnerable to arsenic contamination	Some baseline data have been collected from U.P Jal Nigam. Field investigations were carried out to get acquainted with the area. Literature review has been done to identify the location or area affected by arsenic in Ballia.
Arsenic risk zone mapping for Ballia district	Work is yet to be started

Analysis and Results: The arsenic concentration data on affected villages in District Ballia were collected from U.P Jal Nigam. The geographic distribution of the beyond permissible concentration of arsenic have been brought in GIS environment, using Google Earth. The data are being analysed using Arc-GIS software with an objective to prepare the risk zone map. Literature on arsenic chemistry and other aspects has been consulted.

4. PROJECT REFERENCE CODE: NIH/GWD/NIH/15-18

Thrust Area under XII five year Plan: Drinking water supply demonstration scheme.

Title of the Project: **Peya Jal Suraksha -** Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply.

Project duration : 30 months (November, 2015 – April, 2018).

Project team:

(i) Dr. N. C. Ghosh, Scientist-G : Project Coordinator and Leader
(ii) Mr. C. P. Kumar, Scientist-G, GWHD: Modeling & analysis of river-aquifer system
(iii) Mr. B. Chakraborty, Scientist-G, RC-Patna ; In-charge for Sahebganj (Jharkhand) and Bojpur (Bihar) sites
(iv) Dr. Y. R. S. Rao, Scientist-F, RC-Kakinada: In-charge for Vishakhapatnam site.
(v) Dr. Anupma Sharma, SC-D, GWHD: In-charge for Mathura, U.P., site.
(vi) Dr. Surjeet Singh, Sc-D, GWHD : In-charge for Agra, U.P., site
(vii) Mr. Sumant Kumar, Sc-C, GWHD: In-charge for Lakshar, UK site.\
(viii) Ms. Suman Gurjar, Sc-C, GWHD: RS & GIS work for all sites.
(ix) Ms. Shashi Poonam Indwar, Sc-B, RC-Bhopal : works related to Sahebganj site together with Mr. B. Chakraborti.
(x) Dr. R. P. Singh, Resource Person, GWHD, Hydrogeological investigations & analysis of all sites.
(xi) Ms. Anju Choudhury, SRA, GWHD: RS & GIS works of all sites.
(xii) Mr. Sanjay Mittal, SRA, GWHD: Field investigations and lab. works.
(xiii) Mr. Ram Chandar, RA, GWHD: Field related works.
(xiv) Scientific staff of Soil-Water Laboratory, GWHD.

Objectives of the Project:

(i) Baseline investigations and development of pilot demonstration sites for riverbank filtration (RBF) in different hydrogeological settings;
(ii) Performance and limitations analysis of RBF schemes;
(iii) Effectiveness of RBF technique in different river-aquifer settings and river flow conditions;
(iv) Analysis of RBF under variable pollutants loads and flood situations;
(v) Development of technical elements for flood-proof water abstraction schemes; and
(vi) Scope of extending the technique in attaining drinking water security.

Background:

Based on the successful demonstration of “Saph Pani” (Saph Pani, 2011-2014) results on “Bank Filtration (BF)” and recommendations of the final Conference of the project, as follow up action on promotion of bank filtration technique in India for different hydrogeological settings to attain drinking water security, Chairman, Governing Body (GB) of National Institute of Hydrology (NIH) and Secretary (WR,RD & GR) in the 75th meeting of NIH’s GB held on 19th January, 2015 desired that NIH should develop 6 (six) pilot demonstrate schemes on BF in different feasible locations particularly in the Ganga basin as implementable R & D project. Based on

that, NIH has submitted the project proposal in the Ministry of Water Resources, River Development and Ganga Rejuvenation, Govt. of India for financial support in the month of April, 2015. The primary purpose of Ministry of WR, RD & GR in developing pilot study schemes in different locations is to demonstrate drinking water department about effectiveness of BF technique in supply of safe drinking water in peri-urban and rural areas.

R & D wing of the Ministry of WR, RD & GR has given concurrence in implementation of the project under the Plan grant of NIH. Director, NIH, based on the concurrence of Ministry has given approval on undertaking the project on 3rd Nov., 2015.

Methodology

Six pilot demonstration schemes in 5 states, viz. One in Uttarakhand (Laksar along Solani riverr), two in Uttar Pradesh (Mathura and Agra along Yamuna river); one in Jharkhand (Sahebganj along Ganga river); one in Bihar (Bhojpur area along Ganga river), and one in Andhra Pradesh (Visakhapatnam area along Gosthani river) have been planned to develop. State Jal Sansthan/PHED/Jal Nigam will be the collaborating partner for the schemes from the respective State. HTWD, Germany will be associated to the project as scientific and technical adviser.

The roles of State Jal Sansthan/PHED/Jal Nigam will be towards extending administrative and logistic supports in the field including identification of sites and providing required land for the scheme and electricity facilities for installation of tube wells and O & M of the pumps. The roles of HTWD, Germany will be in cooperation and technical guidance on scientific aspects of the schemes. A schematic line-diagram showing involvement of collaborating partners is given in **Figure 1.**

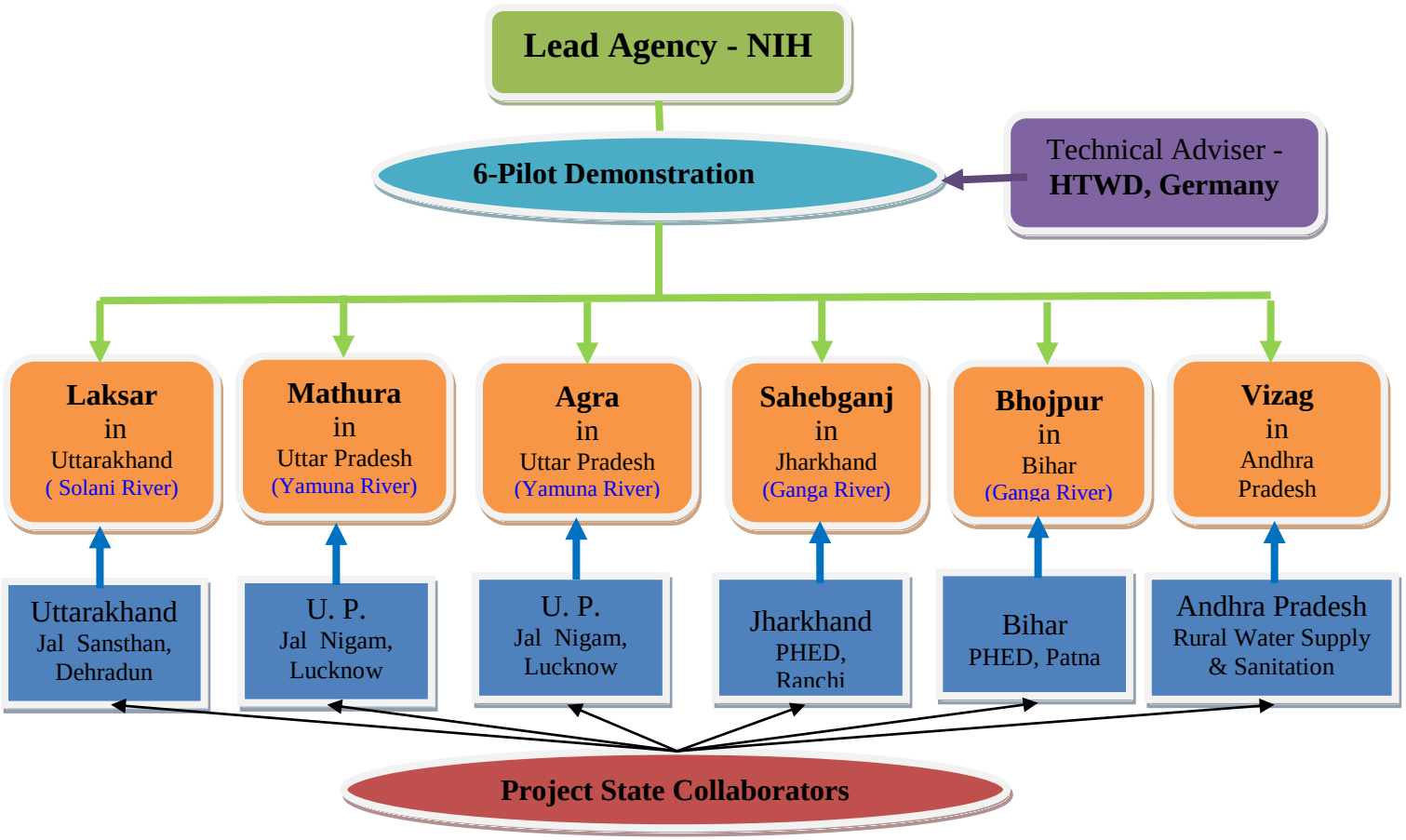


Figure 1 : Involvement of collaborators in different pilot schemes.

Project deliverables

As deliverables, six schemes demonstrating effectiveness of 'Riverbank Filtration' technique for sustainable drinking water supply in different hydrogeological settings, river hydraulic and groundwater conditions will be developed and these schemes after thorough investigations will be handed over to the respective state 'Jal Sansthan' to use them as the guiding scheme towards attaining drinking water security. Few officers from different states will also be trained on scientific and technical aspects of "Riverbank Filtration" technique. This aspect can be regarded as the capacity building on advanced tools and techniques of the state water supply department.

Budget Estimate

Budget estimate is comprised of Personnel cost, travel, exploration works, development of schemes, field investigations and experimentation, laboratory analysis & chemical cost, running cost of the schemes, equipment cost, training and dissemination cost, and miscellaneous. NIH will have complete control on budgetary allocation and it will get the some works done through outsourcing from the partner organization or from other potential sources. The year-wise details of budgetary requirement are as follows:

Sl. No.	Item		Amount in lakhs of Rupees			
			I Year	II Year	Last 6 months	Total
1.	Personnel cost	NIH's personnel	27.2	27.2	14	**68.4**
		Hired Personnel	22	22.8	11.2	**56**
2.	Travel cost		6	6	2	**14**
3.	Development of schemes & Installation works		120	-	-	**120**
4.	Running cost of the schemes		18	18	9	**45**
5.	Experimental cost i/c investigations & consumable items		15	15	5	**35**
6.	Submersible Pumps assembly & Equipment cost		20	-	-	**20**
7.	Training and dissemination i/c LED TV & 2 lap tops		4.5	4.5	4.5	**13.5**
8.	Miscellaneous		1	1	2	**4**
Total			**233.7**	**94.5**	**47.7**	**375.9**

Total Rupees three crore and seventy six lakh.

Activity Schedule

The timeline of different tasks/activities is shown in the following bar diagram.

M* : Month , T (*,*) : Task

Work elements	First Year				Second Year				Third Year	
	M3	M6	M9	M12	M15	M18	M21	M24	M27	M30
Engagement of project personnel (T 1)										
Diagnosis survey & site selection (T1.1)										
Site preparation (T 1. 2)										
Baseline data collection (T1. 3)										
Development of scheme, Installation of tube well, flood protection and										

water supply line, etc. (T 1.4)										
Procurement of pumps & equipment (T 1.5)										
Engagement of field people (T 1.6)										
Sampling campaign and data analysis (T 2.1)										
Operation of pumps and water supply (T2. 2)										
Performance evaluation & risk assessment (T 2.3)										
Interim report (T 2.4)										
Brainstorming workshop (T 2.5)										
Interaction with beneficiaries and utility groups (T 2.6)										
Training & Dissemination (T 3.1)										
Result finalization & Report preparation (T 3.2)										

Progress made so far

The study was initiated in April, 2015 as NIH internal work programme for the year 2015-16.

During the period, progress made is as follows:

- review of literature on the selection of suitable site is completed.
- meteorological data, river flow data at Agra GD site, soil and land use data are collected.
- preparation of various thematic layers is completed.
- invoice for groundwater level data of Agra and Mathura is collected.
- two lithologs along Yamuna river for Agra city are collected.

- made two field visits and collected water samples (river and groundwater) for water quality and isotopic analysis and held interactions with various line departments.

Following particulars are under progress:

- invoice for lithologs and water quality data of Agra and Mathura is awaited from Ground Water Deptt., Agra.
- river flow data of Mathura is under process and will be collected by 20th Nov., 2015.
- analysis of meteorological data and river flow data is under progress.

The results are summarized as follows:

Soils: The soil of Agra is loose, sandy and calcareous and is characterized by alluvium, which is an admixture of gravel, sand, silt and clay in various proportions. Mathura consists of ravenous saline, alkaline and water logged soil but mostly alluvial soils are those formed by the silt of Yamuna and Gang Canal, which are quite fertile whereas, the district is also having large number of water logged areas and patches of usar soils, which are mainly found in Chhata, Goverdhan and Nandgaun blocks.

Geology: Agra and Mathura areas are represented by Gangetic alluvium which is named as Varanasi Alluvium. This formation has a wide spread and it is overlain on the basement formed by the rocks of Super Vindhyan Group of Neoproterozoic age at Agra. The basement in Mathura area is formed of the rocks of Delhi System of Precambrian age which are divided into Alwar Series and Ajabgarh Series while basement in Agra area is formed of the rocks of Vindhyan system. Channel Alluvium occurs on the beds of rivers and *nallas*.

Analysis of **water quality samples** indicates:

- Electrical conductivity is higher (Agra: 1176-1980 µS/cm; Mathura: 999-3020 µS/cm)
- Fluoride is higher (Agra: 1.64-1.90 mg/L; Mathura: 0.53-1.82 mg/L)
- Nitrate is higher (Agra: 8.11-60.82 mg/L; Mathura: 14.23-70.69 mg/L)
- pH, chloride, sulphate, calcium and magnesium are within permissible limits.
- Among anions, Cl^- is the most dominant and the anions contribution in descending order is as: $Cl^- > SO_4^{--} > HCO_3^- > NO_3^- > F^-$, while among cations: Na^+ is found dominant and the contribution by the cations in descending order is as: $Na^+ > Ca^{++} > K^+ > Mg^{++}$.
- The results of the analysis reveal that majority of the groundwater samples are suitable for drinking and irrigation purposes.

Analysis of isotopic samples indicates:

- The isotopic analysis with water quality investigations reveal that the groundwater is highly influenced by the river Yamuna.

Based on preliminary investigations, groundwater, containing river seepage component, signifies low temperature, low EC and depleted isotopic (δD) composition. The influence of river on groundwater is found to decrease with the increasing distance from the river. The contribution of river water to the groundwater is more in Mathura as compared to Agra.

5. PROJECT REFERENCE CODE: NIH/GWD/INT/15-16

Title of the Project: Web Enabled "Groundwater Recharge Estimation Model (WE-GREM) "

Project team

Project Investigator	Ms. Suman Gurjar
Co- Project Investigator	Dr. N. C Ghosh
Investigator(s)	Mr. Sumant Kumar
	Dr. Surjeet Singh
	Dr. Anupma Sharma

Type of study: Internal

Nature of study: Outreach Services.

Duration: August 2015-March 2016

Objectives:

- To develop a comprehensive user friendly web-enabled time-varying "*Groundwater Recharge Estimation Model*".
- To provide a platform to users and professionals for calculating time-varying depth of water in, and groundwater recharge from, a surface water body without using any third party software.
- To facilitate users and professionals in estimation of groundwater recharge from a large surface water body and depth of water in it and to visualize the output in graphical as well as tabular format.
- To host the module in the public domain for its large uses by stakeholders and groundwater professionals.

Present state-of-art:

Usually to calculate the groundwater recharge from surface storages the proprietary desktop software's and analytical models are used, which an individual has to purchase for the first case or develop for the later case. Groundwater recharge from a large waterbody for variable inflows and outflows is also varied on time due to varying potential heads, and thus involve a complex computation hazards. The web-enabled application provides a platform in calculating recharge and corresponding depth of water in the surface waterbody, if the computational tool is adequately developed.

Methodology:

- A semi-analytical mathematical model to estimate unsteady groundwater recharge resulting from variable depth of water in a large waterbody, influenced by time variant inflows and outflows has been developed by Ghosh et. al.

(2015).

- The model has been derived by integrating Hantush's (1967) analytical expression for water table rise due to recharge from rectangular basin into water balance equation of waterbody.
- The model has provision of direct inputs and to calculate of various hydrological components of the water balance equation. These components include evaporation rate, inflow rate, outflow rate, rainfall etc.
- The module has the platform to provide direct values of input variables and also to calculate the variable using mathematical equations. For example, to calculate inflow rate from rainfall, SCS-CN method is used, and to calculate evaporation rate Pan Evaporation Method, Mass Transfer Method and Priestley-Taylor Method are used.
- The results will be in the form of graphical format, interactive charts and tables.

Progress made so far:

- Source code is developed using HTML and JavaScript and validated with the field data.
- Graphical user interface has been created.
- The input from user is in the form of excel sheet and give results in the form of interactive chart and tabular form.
- The results in tabular and image format have option to save.
- To calculate the evaporation rate and inflow rate using different analytical methods on the fly is under development.
- Contour map generation and regress testing with various dataset is part of subsequent development of project.

References:

Ghosh, N. C., Kumar, S., Grützmacher, G.,Ahmed, S.,Singh,S., Sprenger,C., Singh,R.P, Das, B.(2015).Semi analytical Model for Estimation of Unsteady Seepage from a Large Water Body Influenced by Variable Flows . Water Resour Manage, DOI 10.1007/s11269-015-0985-z.

6. PROJECT REFERENCE CODE: NIH/GWHD/BGS/2015-16

Title of the study	**:**	**Groundwater Fluctuations and Conductivity Monitoring in Punjab**
Name of PI and members	**:**	**NIH, Roorkee, India:** Dr. N. C. Ghosh (project coordinator) Dr. Gopal Krishan (PI) Dr. Surjeet Singh (co-PI) **BGS, UK:** Dr. Dan Lapworth (PI) Prof. Alan MacDonald (project coordinator)
Type of study	**:**	Sponsored by BGS, UK.
Date of start (DOS)	**:**	January 2016
Scheduled date of completion	**:**	December 2017
Location	**:**	Bist- Doab Punjab

Study objectives:

1. Monitoring of groundwater level fluctuations and conductivity in 4 piezometers installed in Bist-doab, Punjab
2. To prepare a status report on groundwater issues in Punjab

Statement of the problem:

The increased use of groundwater to meet out the ever increasing demands of growing population, agricultural and developmental activities leading to groundwater depletion. Such patterns of steady groundwater decline are witnessed in many parts of the country, particularly Punjab (Krishan et al., 2014; Rodell et al., 2009) where the annual rate of groundwater level decline is increasing by about 80% during 1980-2005 (Singh, 2011) and is projected to fall by about 21 meter in 2/3rd area of central Punjab during next 2 decades (Sidhu et al., 2010).

In the study area, occurrence of groundwater forms the multi-layered aquifer system. The groundwater fluctuation in the shallow aquifer and deep aquifer show different trends. The large drop in groundwater levels can be due to several reasons like high withdrawals, low-recharge, low-transmissivity, poor conditions of surface water recharge source conditions etc.

The sustained growth in the agricultural sector in Bist-Doab catchment of Punjab has only been possible through the use of irrigation from shallow local groundwater sources as well as an extensive canal network that redistributes water from the Himalayan watershed to the plains. Recent satellite based observations have shown that there is a significant net loss in terrestrial water storage (TWS) in this region. This approach has been useful as part of large scale assessments of changes in TWS, but there is a high degree of spatial heterogeneity in groundwater flow processes that is masked by this regional approach. Characterising and understanding the reasons for this local heterogeneity is fundamental to develop effective water management plans. This requires higher resolution field-based observations.

Considering these facts it is proposed to prepare a report on the monitoring of groundwater fluctuations and conductivity across heavily groundwater exploited region of Punjab.

Whether Study is a New Study/Extension of Previous Studies: New Study

Methodology:

In this study, groundwater level and conductivity data will be monitored and high resolution field based observations will be collected. For this the loggers for water level and conductivity have been installed in 4 shallow piezometers of PWRED, Chandigarh at Saroya (Kandi region), Bhogpur, Kapurthal and Sultanpur Lodhi.

Action plan:

Year	Jan. 2016 to Dec., 2017	Remark
Jan. 2016 to Dec. 2017	Literature review on available groundwater studies including water table, water quality and other hydrogeological aspects in Punjab Monitoring of water level and conductivity fluctuations in Bist-Doab, Punjab Prepare a status report on groundwater issues in Punjab Presentation of work progress in a workshop/review meeting under the project	Report preparation as per Annexure 1

Study Benefits /Impact:

- An overview report on groundwater status in Punjab
- Research publication in high impact journals.
- Upload of results on Websites.

Specific linkages with Institutions: BGS, UK

Activity Schedule for the Groundwater Fluctuations and Conductivity Monitoring in Punjab (Quarter-wise from Jan. 2016 to Dec. 2017)

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th
Downloading data	♦		♦		♦			♦
Collection of data from various agencies (NIH)	♦	♦	♦	♦	♦	♦		
First Draft (NIH-BGS)				♦				
Second Draft Report/Technical publication(NIH-BGS)				♦				
Final Report/Publication(NIH-BGS)							♦	♦

Data requirement & Expected source:

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

IPR potential and issues **:** Nil

Major items of equipment needed **:** None

HYDROLOGICAL INVESTIGATIONS DIVISION

ITEM NO. 43.2 ACTIONS TAKEN ON THE ADVICE / DECISIONS OF THE 42nd MEETING

Actions taken pertaining to individual studies, if any, are discussed separately for each study under the Item No. 43.3.

ITEM NO. 43.3 PROGRESS OF THE WORK PROGRAM OF THE DIVISION FOR THE YEAR 2014-15

As per the approved work program during the 42nd meeting of working group held on 19th – 20th March, 2015, the Hydrological Investigations Division had to carry out 7 R & D studies, 5 sponsored projects and 2 consultancy project (See annexure-I). Status of studies carried out during 2015-16 is given below:

Type of study/Project	***Completed in FY 2015-16 (Till Dec, 15)***	***Continued in FY 2015-16 (Cont. after Dec, 15)***	***New Study Proposed / started***	***Total studies / projects in progress***
R & D Studies	2	5	-	5
Sponsored Projects	1	3 + 1 (Yet to be started)		3 + 1 (Yet to be started)
Consultancy Projects	0	2	8	10
Total	3	10	8	18

The progress and the results of the internal studies and the sponsored projects is given below:

R & D STUDIES:

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

Thrust Area under XII five year Plan: ***Dynamics of deeper aquifers***

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

Project Team:

(a) Project Investigator : Sudhir Kumar (PI)

(b) Project Co-Investigator(s): C. K. Jain, S. P. Rai, S. D. Khobragade, P. K. Garg,
Two officers each from Lucknow and Chandigarh Regional Offices of CGWB

Duration : July 2013 to June 2015

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

Details of the work done are given under sponsored project "Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains"

The results of the samples sent to IAEA Vienna are still to be received and analyzed. Therefore it is requested that the project be extended till March, 2016.

2. *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**

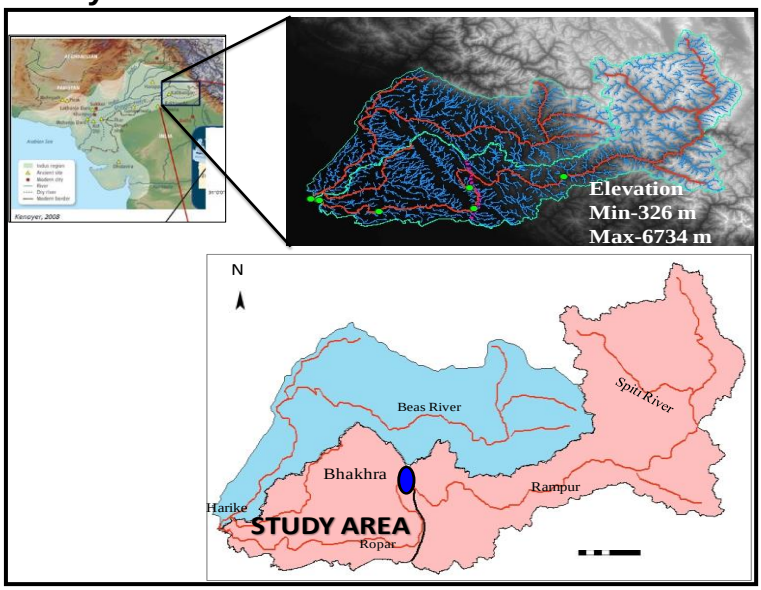
Study Team : S. K. Verma (PI), S. P. Rai (Co-PI), M. S. Rao, C. P. Kumar, and Mohar Singh

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

Present State-of-Art:

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.

Research outcome from the project:

i. Generation of data base for radon concentration & groundwater age
ii. Publication of report and research papers

Objectives vis-à-vis Achèvements:

Sr. No.	Objectives	Achievement
1.	To measure radon concentration in water	Completed
2.	To identify paleo-groundwater in the study area	Completed

Analysis and Results

- The analysis of radon concentration has been carried out for a total of 54 groundwater samples collected from intermediate/deep aquifers using tube wells for drinking water supply from different locations in the study area. The values of radon concentration obtained fall well below the safe limit recommended by the World Health Organization (WHO) for drinking water purpose.
- The electrical conductivity has been measured at 54 locations for the groundwater samples collected from intermediate/deep aquifers using tube wells for drinking water supply from different locations in the study area. The electrical conductivity varies from 250 µS/cm to 1180 µS/cm in the study area.
- The stable isotopes analysis ($\delta^{18}O$, δD) has been carried out for a total of 39 groundwater samples collected from intermediate/deep aquifers using tube wells for drinking water supply from different locations in the study area. The variation of stable isotopes ($\delta^{18}O$, δD) with radon concentration for groundwater samples as collected above has been studied.
- In addition to above, a total of 39 ground water samples collected from intermediate/deep aquifers using tube wells for drinking water supply have been analysed for environmental tritium analysis available in Nuclear Hydrology

laboratory. The analysis of 15 groundwater samples for environmental tritium analysis is in progress in the laboratory.

The results of various analyses will be presented during the working group meeting.

The study has been completed and draft report is being prepared.

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

Title of the study : Interaction between groundwater and seawater along the parts of east coast of India

Study Team:

a) NIH: M. Someshwar Rao (PI), Dr Sudhir Kumar (Co-PI), Sh. S. K. Verma & Sh Pankaj Garg

b) Technical Collaborators: Sh. Niladri Naha, Addl. Director, SWID, Kolkata, and Dr. Abhijit Mukharjee; Asstt Prof., IIT-Kharagpur

Type of Study : Internally funded
Budget : Rs. 26,82,000/-
Date of Start : April, 2015
Date of Completion: March 2017
Study Objectives :

The objectives of the study are:

i) Mapping the salinity variation and stable isotopic composition in the coastal groundwater
ii) Mapping the dissolved radon in groundwater and its implication to fresh groundwater discharge to sea or sea-water intrusion
iii) Mapping the groundwater-seawater interaction regions vis-à-vis the operating hydrological process (SGD/Seawater intrusion)

Statement of the Problem

India has a very long coastline and 25% of the country's population lives in the coastal zone. The growing population density along the coastline is causing increasing groundwater demand and its exploration in the coastal zone. With the increasing water withdrawal problems like salinity hazard, seawater intrusion, salt water upconing, land subsidence etc., are getting witnessed. The distribution of fresh water aquifers in coastal aquifer is controlled by several factors like in-flux of sea water into surface water sources (streams, lagoons etc) and recharge contribution from these sources to the local groundwater; hydraulic connection of groundwater with the sea and the gradients that are set up naturally due to tidal effects and groundwater withdrawals; leaching of surface salts etc. The case is of seawater intrusion if the freshwater-saline water interface lies within the continental land mass and in case higher hydrostatic pressure of fresh-groundwater; the fresh-groundwater may gets discharged into the marine zone leading the submarine groundwater discharge (SGD). The change in sea level (due to climate change or tidal effects) and groundwater levels (due to excess withdrawal, land use change, climate change etc.) influence both SGD and SI. While SGD is the direct loss of freshwater to sea, the seawater intrusion causes groundwater salinization thereby reducing the available freshwater volume. With the growing freshwater demand mapping of freshwater & seawater intrusion zones, seawater-groundwater interaction pathways and management for sustainability of freshwater resource in coastal zone is increasing. With this background, in the present study, the mapping of fresh-groundwater discharge and seawater intrusion mapping is being planned to conduct along the parts of the east-coast of India.

Brief Methodology

The decay of radioactive ^{238}U present in the groundwater aquifer matrix releases ^{222}Rn as one of its daughter members in its decay series. The released ^{222}Rn

remains in groundwater as dissolved gas and its concentration in groundwater depends upon concentration of its immediate parent member ^{226}Ra, any loss of the ^{222}Rn gas due to possible escape to atmosphere (usually occurs in recharge and discharge zones) and its decay to its daughter product ^{218}Po as per the half-life of the ^{222}Rn ($t_{½}$ =3.8 days). Therefore, high concentration of ^{222}Rn is usually observed in confined groundwater conditions and decreasing concentrations when the groundwater encounters recharge or discharge zones. Stable isotopes of water (δ^{18}O, δD) provide an easy means to track seawater-groundwater interaction by knowing the isotopic composition of the end members; fresh groundwater and seawater (~0‰). While mixing with seawater enriches stable isotopic composition of fresh groundwater towards 0‰ (and also increases the groundwater salinity and reduces dissolved ^{222}Rn concentration); the leaching of salts will only increase dissolved salt concentration (and no change in stable isotopic composition but possible reduction in ^{222}Rn concentration due to its escape to atmosphere). Therefore, through measurement of EC, concentration of dissolved ^{222}Rn, and stable isotope composition it is possible to track the groundwater dynamics in the coastal zone and the interconnection with seawater. Measurement of, ^{3}H in groundwater additionally can be used to get the groundwater age and time scales of these processes.

Action Plan: The field work shall be conducted on West Bengal and Odisha coast during 16-28 November, 2015. During the field-work it is planned to collect groundwater samples from 10 cross sections between Kolkata (in West Bengal) to Puri (in Odisha) with 3-4 samples along each cross sections spanning a distance of ~5-8 km from the coast line. During groundwater sampling ^{222}Rn concentration and EC measurement will be done in-situ and geo-coordinates of the sampling locations will be recorded. Since the sampling locations are far-off from Roorkee, local persons will be hired for collection of groundwater sampling at least one in every month from each sampling site for stable isotope measurement purpose.

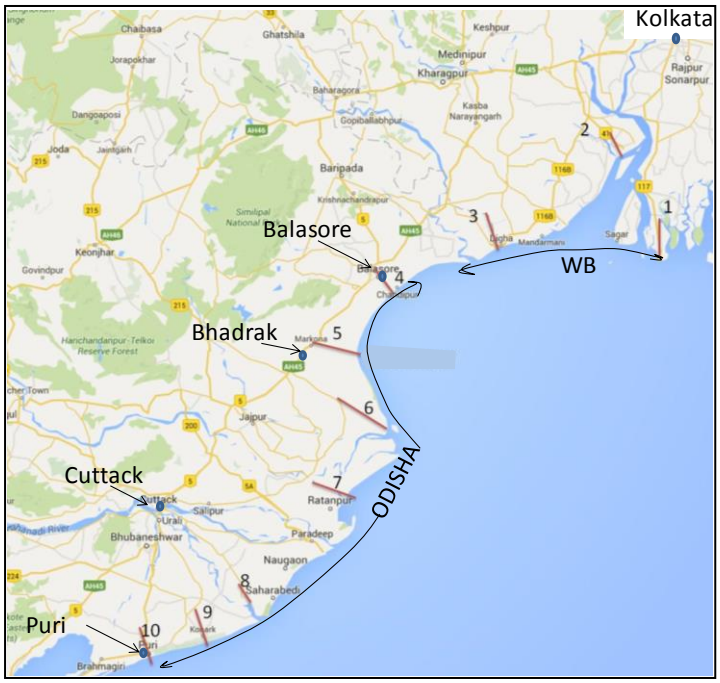


Fig: Cross sections (1-10) along which groundwater samples are being planned to be collected during Nov., 2015

The collaborating institute (Dr. Abhijit Mukharjee, IIT-Kgp) has provided 400 pore water samples collected from Chandipur sea coast. The samples were collected from multiple depths along 4 cross sections during Jan-2014, May-2014, Sept-2014 and Jan-2015.

Action Plan

Sl. No.	Work Element	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	5th Qtr	6th Qtr	7th Qtr	8th Qtr
1	Field work for water sampling and data collection	~~✓~~		✓					
2	Sample analysis		✓	✓	✓				
3	Data interpretation, interim report, publications			✓	✓				
4	Training programme/ workshop				✓				
	Field work for water sampling and data collection					✓	✓		
	Sample analysis					✓	✓	✓	
	Data interpretation, Final report, publications					✓	✓	✓	✓

The action plan for the next 6 months is given below:

1. Analysis of water samples collected along 10 cross sections along Odisha-West Bengal coastline for stable isotope and ^{3}H details
2. Analysis of pore-water samples collected from Chandipur sea-bed for stable isotope details.
3. Collection of groundwater samples of pre-monsoon period along Odisha-West Bengal coastline.
4. Collection of supporting data.

Objectives vis-à-vis Achievements: Collected pre-post monsoon pore-water samples from multiple depths along 4 cross-sections from Odisha, Chandipur coast. Some delay in the remaining work occurred due to delay in release of funds by four months. Accordingly, the work-plan as proposed got shifted by one quarter of the year.

4. 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), Sudhir Kumar (CO-PI), Prof. A. L. Ramanathan, JNU (Technical Collaborator)
Type of Study : Internally funded
Budget : Rs. 32.68 lakhs
Date of Start : April, 2015
Date of Completion: March 2017
Study Objectives :

i) Generating the primary isotope data on snow, glacial cores and on glacial discharge of benchmark Himalayan glaciers
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

Statement of the Problem

Himalayan glaciers are the major sources of fresh water for the livelihood of population of northern India and it exters strong influence over the river flow of several major rivers like River Ganga, River Yamuna, River Indus, River Brahamaputra and their tributaries by storing and releasing water in accordance with the climate of this region. Climate change (e.g. temperature and precipitation) results into advancement/ recession, of these glaciers. Therefore, the glaciers are considered to be as a sensitive indicators of climate change. Globally, climate change has been projected to cause major changes in glacier, snow and their melt contribution to streamflow.

Stable isotopic composition of precipitation reflects the integrated effect of source of origin of air-moisture and the local weather conditions during the precipitation. The isotopic composition of the snowpack profile generally represents the distinct isotopic composition of individual precipitation events. Evaporation, sublimation, mixing with snow melt, density change etc., averages, modifies and complicates the isotopic signatures of individual precipitation events in the snowpack. Mixing with different source of moisture, altitude of precipitation, breaks in precipitation, local weather conditions during precipitation controls the isotopic composition of the precipitation and the isotope regression line of local meteoric water (LMWL). Melt water leaving the snowpack at different altitude from high steep ranges is the result of different stages of snowmelt in larger basin with varied altitude. The present project is taken-up to investigate these complications on a few important benchmark Himalayan Glaciers.

Brief Methodology

The study involves sampling of melt water of glacial channels, snow cores, precipitation and their isotopic analysis. The data will be used to develop LMWL and in understanding the effect of local weather in modification of isotope systematic of the snow accumulation & melting.

Action Plan:

Sl. No.	Work Element	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	5th Qtr	6th Qtr	7th Qtr	8th Qtr
1	Purchase of equipments and items for study, hiring of project staff etc	✓	✓						
2	Field work for water sampling, installation of equipments in the field (precipitation, air-moisture, snow & snow melt, river water, groundwater and spring water etc)		✓						
3	Sample analysis		✓	✓	✓				
4	Data interpretation, interim report, publications			✓	✓				
	Field work for water sampling						✓		
	Sample analysis					✓	✓	✓	
	Data interpretation, publications					✓	✓	✓	✓
	Training programme/workshop, Final report							✓	✓

Since the budget for the field work could not be received before the month of August, the work was mainly relied on the field-work conducted by the coordinating institute (Prof. AL Ramanathan, JNU, New Delhi). The coordinating institute extended the samples collected from Chhota Shigri glaciers by them during 2013. The samples collected include fresh snow samples from altitudes: 4900 m, 5000 m, 5100 m and 5190 m above msl; old snow samples from altitudes 4900m & 5100 m above msl; rain samples from base camp at altitude 3877m above msl and using AWS at 4756 m above msl. The melt-water was collected from altitudes 4392 m, 4710m, 4050m and 3850m above msl. The snow core was sampled over 4 m length at every 50 cm intervals. These samples are being analyzed for isotopic details in NIH laboratory and the interpretation of the results is in progress. The analyzed results will be presented in the meeting of the Working Group.

Future Plan: The work for the next one year includes sample collection from a few more glaciers, analysis & interpretation of data and writing of report & research papers. Since deciphering the climate signal requires long ice cores, required purchases towards raising long ice cores and for bringing them intact to laboratory, cryo-box will be fabricated. The developed facility can also be used for any future projects.

5. 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. S. Rao
Type of Study : Internal
Date of Start : January 2015
Date of Completion: December 2015

Study Area: Haridwar district 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 pre 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.

Study 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.

Statement of the Problem

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.

Brief Methodology

In order to study the radon contamination in the study area at different locations, groundwater samples from shallow as well as deeper aquifers for pre and post monsoon seasons will be collected for in-situ radon measurement for studying the spatial and temporal variation of radon concentration. The hydro-geological data will also be collected for the study area in order to study the hydro-geological features to be linked with the radon concentration in pre and post monsoon season groundwater samples.

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**			√	√

Objectives vis-à-vis Achievements

Sr. No.	**Objective**	**Achievement**
1.	Mapping the spatial distribution and temporal fluctuation in radon levels in groundwater in Haridwar district.	A total of 25 samples have been collected from different parts of Haridwar district and analysed from radon concentrations
2.	To investigate the effect seasonal groundwater levels fluctuations on fluctuation in radon levels.	Samples for post monsoon season have been collected and are being analysed .

Analysis and Results

- The ^{222}Rn activity was measured in 25 representative groundwater samples and the values of ^{222}Rn ranged between 0.55 ± 0.14 and 21.01 ± 6.43 Bq L^{-1} with an average value of 6.79 ± 0.37 Bq L^{-1} and 84% of samples were well within the EPA's maximum contaminant level of 11.1 Bq L^{-1} while 16% of samples were above the EPA's maximum contaminant level of 11.1 Bq L^{-1}

- EC values ranged between 240 - 970 µS/cm with an average value of 494 µS/cm; pH values ranged between 6.7-7.9 with an average value of 7.4 and temperature values ranged between 18.5 - 30.4 ^{o}C with an average value of 23.5 ^{o}C.
- Radon values were computed for correlation coefficient with other parameters viz. EC, pH and temperature and it was found that EC has a weak, pH has a modest negative and temperature has a high & significant correlation, respectively with radon concentration.

Publications:

1. Garg, P.K., Krishan, Gopal and Kumar, Sudhir 2015. *Radon concentration in groundwater of Haridwar, Uttarakhand, India*. *International Journal of Earth Science and Engineering*. **8(2):1-4**.
2. Krishan, Gopal, Garg, P., Kumar, S. 2015. *Occurrence of Radon in Groundwater of North-western India: An Overview*. In: Proceedings of an International conference on "Annual Water Resources Association 2015 AWRA" during 16-19 November, 2015 at Denver, Colarado (accepted).
3. http://www.awra.org/meetings/Denver2015/ doc/PP/Sess%2040%20abs.pdf
4. Garg, P., Krishan, Gopal, Kumar, S. 2015. *Measurement of radon concentration in groundwater using RAD7 in Roorkee area of Uttarakhand, India*. In: Proceedings of 20th International conference on Hydraulics, Water Resources and River Engineering- Hydro-2015 during 17-19 December, 2015 at IIT-Roorkee (accepted).

Future Plan: As per activity chart

6. *PROJECT REFERENCE CODE: NIH/HID/INT/2015-16/1*

Title of the Study: **Hydrological Aspects of Rewalsar Lake, Himachal Pradesh (Status Report)**
Project team: Suhas Khobragade (PI), Sudhir Kumar, C. K. Jain, V. K. Agrawal, and Satya Prakash
Type of Study: Internal Study
Budget: 3.27 Lakh
Date of start: **April, 2015**
Duration: **1 year**
Date of completion: **March, 2015**
Study Objectives:

1. To determine the environmental status of the lake
2. To identify major problems of the lake
3. To identify major management issues of the lake
4. To review current research status and research needs for lake
5. To review the data availability scenario and identify data gaps vis-a-vis identified research needs

Study Area: Rewalsar Lake, or Tso Pema Lotus Lake, is a mid-altitude lake located in Rewalsar town in Mandi District in Himachal Pradesh, 22.5 km south-west from Mandi. It lies between 31º37’30" N and 76º49’15" E at an altitude of 1360 meters above sea level. It is a small natural lake with a shoreline of about 735 meter and 175 hectare catchment area. The shallow lake has the maximum depth of 6.5 m. The lake is significant from religious, cultural and tourism purposes. It is held as a sacred spot for Hindus, Sikhs and Buddhists alike.

Fig. 1: A view of Rewalsar Lake, Mandi (H.P.)

Statement of Problem:
Water quality degradation has been reported for the lake. Due to pollution the nature of water has turned acidic (Tribune India, May 11, 2010). The poor sewerage system of Rewalsar town is further increasing the problem as contaminated water directly flows into the lake (Tribune India, May 11, 2010). According to the news published in the Tribune (May 14, 2014), more than 700 fish died during May 2014 at Rewalsar Lake. The death of fish is a regular feature of the lake but no systematic studies

have been reported for the lake. No hydrological studies have been reported for the lake so far.

Brief Methodology:
The envisaged objectives will be achieved through:

a) Collection, processing and analysis of the available data
b) Review of literature
c) Field survey
d) Interaction with management authorities and local people
e) Collection and laboratory analysis for water sample/sediment samples for water quality and isotopic characteristics

Action Plan:

Sl. No.	Work Element	First quarter	Second quarter	Third quarter	Fourth quarter
	Literature Review	√	√		√
	Collection and compilation of all available data/information	√			
	Purchase of instruments	√			
	Preparation of study area maps		√		
	Procurement of data	√			
	Collection of water samples for water quality analysis	√	√		
	Collection of sediment samples	√			
	Lab. Analysis of water and sediment samples for Water Quality	√			
	Water quality assessment of the lake		√	√	
	Identification major problems, data gaps and research gaps				√
	Preparation of interim report	√	√		
	Preparation of final report				√

Objectives vis-à-vis Achèvements

Sr. No.	Objective	Achievement
1.	To determine the environmental status of the lake	Water quality assessment has been carried out
2.	To identify major problems of the lake	Achieved
3.	To identify major management issues of the lake	Under progress
4.	To review current research status and research needs	Have been done based on the present understanding of the problems

	for lake	
5.	To review the data availability scenario and identify data gaps vis-a-vis identified research needs	Under progress

Results and Analysis:

Water quality sampling was carried out during the month of July 2105 and the analysis has been completed. It has been observed that in general the lake water quality of Rewalsar Lake is good. The concentration of most of the parameters is generally low. This could be the dilution effect caused by the water received from the rain as direct fall over the lake. Further,
It was observed that except for Sulphate, DO and BOD, concentration of most of the parameters at different locations in the lake varies in a low range indicating that in general the lake water is well mixed. This may be due to the fact that shallow depth makes it easy for the wind to mix the lake water, aided by the rain falling directly over the lake. High DO (average value of 12.21 mg/l) along with very low value of BOD (average value of 0.73 mg/l) clearly indicates absence of organic pollution in the lake. The results of the bacteriological parameters for the lake indicate that Total coliform value ranged between 240 and 2400 per 100 ml at the three locations. As far as faecal coliform is concerned, it was in the range of 210-280 MPN/100 ml at the three locations.

Isotopic analysis of the lake and surrounding ground water has also been carried out. The values of $\delta^{18}O$ for the lake are observed to vary in the range of -1.79 ‰ to -1.53 ‰ while corresponding δD values range between -12.65 ‰ and -10.85 ‰. The surrounding groundwater shows different isotopic characteristics than the lake water. For the surrounding groundwater (which includes samples from hand pumps and springs) the values of $\delta^{18}O$ are observed to range between -6.28 ‰ to -4.81 ‰ while those of corresponding δD range between -38.94 ‰ and -23.28 ‰. Thus, it can be observed that the values observed in the lake are highly enriched compared to the surrounding groundwater due to evaporation effect.
Sedimentation in the lake has been determined using Cs-137 technique. Sediment core was collected from the lake and was analysed for Cs-137 activity. The results are shown in Fig. 2. Based on the analysis, rate of sedimentation for the Rewalsar lake comes out to be 0.82 cm/year.

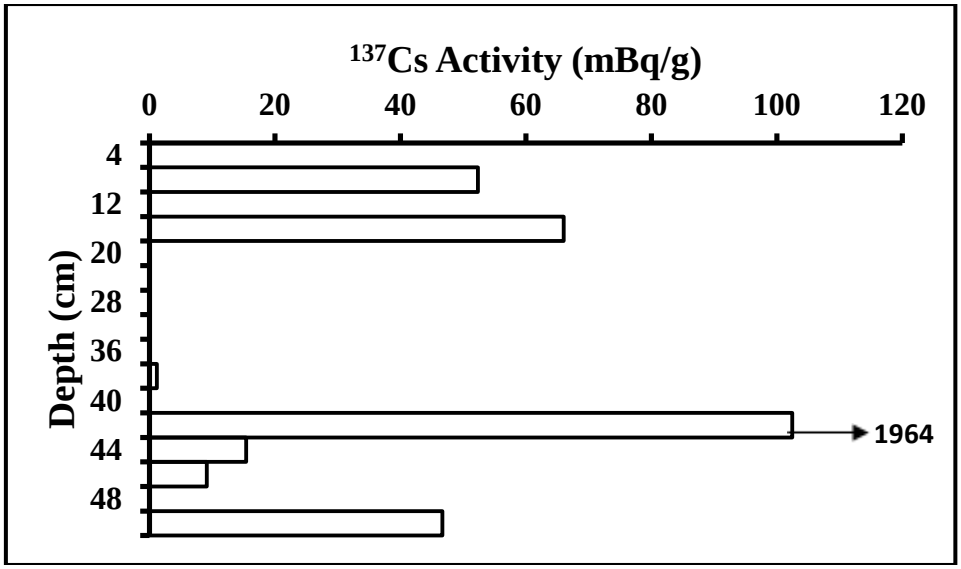


Fig. 2: Depth-wise activity plot for samples in the sediment core

The analysis carried out so far indicate higher sedimentation rate for the lake. Analysis of isotopic data of inflow water and surrounding groundwater does indicate possible contribution of surrounding groundwater in the lake. However, analysis of water quality data particularly the high DO values, fail to explain dying of fish during summer. Further analysis of water quality is suggested with analysis of seasonal variation and particularly the summer water quality.

Future Plan: As per activity schedule

7. *PROJECT REFERENCE CODE: NIH/HID/INT/2015-18/1*

Title of the study: **Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh**
Study Team: **Suhas Khobragade (PI),** Sudhir Kumar, Senthil Kumar, P Garg, Sh. V. K. Agrawal and Satya Prakash
Type of Study: **Internal**
Budget: **59.59 lakh**
Duration: **3 years**
Date of Start: **April, 2015**
Date of Completion: **March, 2018**
Action taken on the suggestion of 42 WG meeting:

S.N.	Suggestion	Action Taken
1.	Dr. Prasad suggested that the first objective may be modified and identification of zones of lake-water interaction may be removed from the objectives as it would not be possible to establish such zones.	The objective has been removed from the study.

Statement of Problem:
Sukhna Lake in Chandigarh faces water scarcity problems especially during the deficit rainfall years. No studies on the interaction of the lake with surrounding groundwater have been reported so far except for the preliminary investigations carried out by NIH. Studies on water balance carried out by NIH do indicate that seepage may be a significant factor determining the water availability in the lake. A careful and detailed studies on this aspect is however needed to understand and establish the lake -groundwater interaction and seepage losses from the lake. Hence the present study has been undertaken.

Study Objectives:
(i) To determine seepage losses from the lake
(ii) To determine the relative significance of seepage losses in overall water balance of the lake

Brief Methodology:
The envisaged objectives will be achieved through –

i) Collection, processing and analysis of the available hydro-meteorological, ground water and isotopic data
ii) Generation of additional hydro-meteorological and groundwater data.
iii) Field investigations including, piezometer installation and monitoring, resistivity survey, bathymetric survey and infiltration tests
iv) Sample collection and laboratory analysis for isotopic investigations Isotopic investigations of water and soil/sediment samples

Action Plan/Timeline:

Sl. No.	Work Element	First Year	Second Year	Third Year
1.	Recruitment of project staff	√		
2.	Literature Review	√	√	√

3.	Collection and compilation of all available data/information	√		
4.	Procurement of instruments	√		
5.	Preparation of study area maps	√		
6.	Procurement of data	√		
7.	Identification of locations for installation of piezometers	√		
8.	Installation of piezometers	√		
9.	Collection of water samples for water quality analysis	√	√	√
10.	Collection of water samples for isotope analysis	√	√	√
11.	Infiltration tests to determine Infiltration rates	√		
12.	Measurement/estimation of discharge	√	√	
13.	Bathymetric Survey	√		
14.	Generation of field data such as water levels of lakes & GW, meteorological data etc	√		
15.	Analysis of water samples for Water Quality	√		
16.	Analysis of samples for isotopes	√	√	√
17.	Isotopic characterization of water in and around the lake	√	√	√
18.	Resistivity Survey	√		
19.	Identification of lake-groundwater interaction zones			√
20.	Determination of Seepage rates		√	√
21.	Determination of Water Balance components	√	√	
22.	Preparation of interim report	√	√	
23.	Preparation of final report			√

Objectives vis-à-vis Achèvements

Sr. No.	Objective	Achievement
1.	To determine seepage losses from the lake	Preliminary results have been obtained
2.	To determine the relative significance of seepage losses in overall water balance of the lake	Preliminary results have been obtained

Results and Analysis:

Analysis of the water balance carried out during previously for different years indicate that 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. However, for further detailed analysis continuous monitoring of the daily water level

data of the lake, and the two piezometers located just upstream and downstream of the lake is being carried out since July, 2015 using automatic water level recorders installed at these three locations. The data are shown in Fig. 2 (a and b). The data does not show any significant seepage during the study period. More detailed analysis shall be presented in the working group meeting.

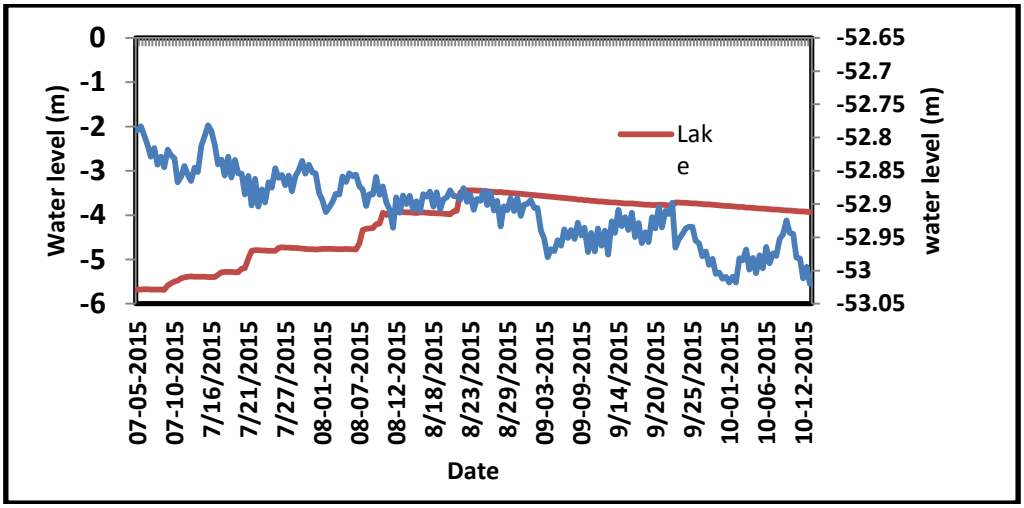


Fig. 1(a): Variation of Pz-1 water level vis-à-vis lake water levels

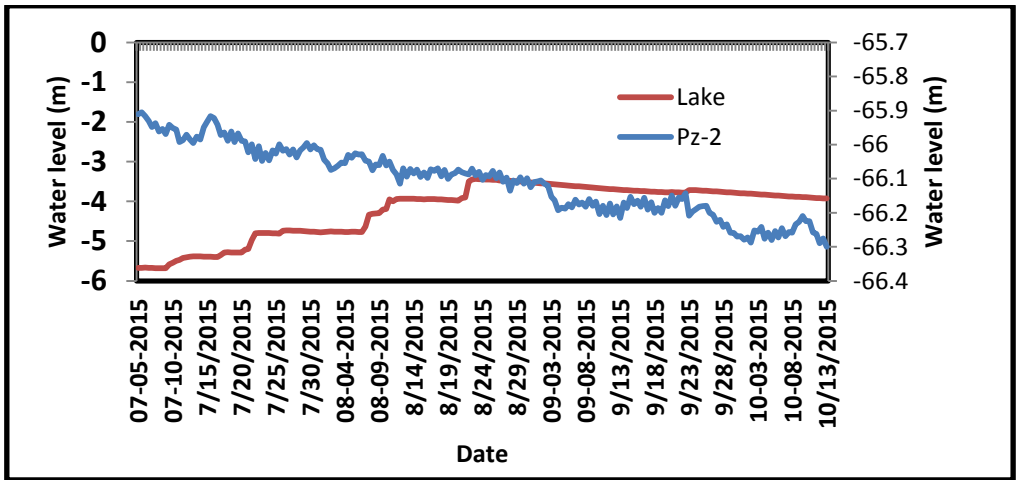


Fig. 1(a): Variation of Pz-2 water level vis-à-vis lake water levels

Future Plan: As per activity schedule

SPONSORED PROJECTS

8. 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

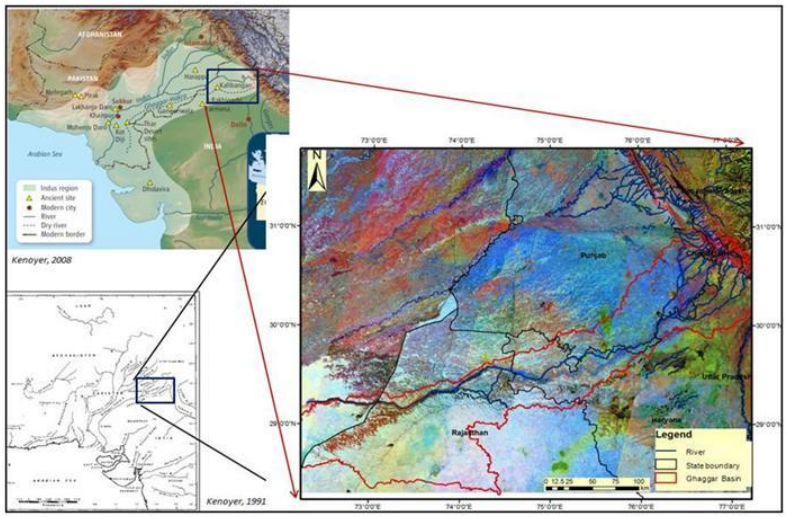
Budget : Rs. 210 Lakh (NIH component Rs. 35 lacs)

Date of Start : June 2012

Date of Completion: May 2015 (extend to March 2016 by MOES, Govt. of India)

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 raising 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**	**13th**	**14th**	**15th**	**16th**
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		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦			
Sample collection and Measurement of ^3H activity of groundwater, rain and river		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		
Sample collection and										♦	♦	♦	♦	♦	♦	

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th
measurement of ^{14}C activity of groundwater																
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 $\delta^{2}H$) of	• Pre-monsoon & post-monsoon samples of groundwater, river and canal have been collected

groundwater, stream and rain water	and laboratory analysis completed.
Groundwater dating using the tritium and Carbon-14	• About 40 samples Tritium dating completed and analysis of 20 samples is in progress. 25 groundwater samples collected for carbon and dating and CFCs, SF6 dating. The samples are send to UK for analysis
Delineation of flow direction and recharge zones	• Water level data and tritium data are used to delineate the flow direction and recharge zones of groundwater. • $\delta^{18}O$, $\delta^{2}H$ and tritium data of groundwater and other sources have been analysed and source identification of the groundwater is in progress.
Identification of recharge source and zones of groundwater in the study area.	• Identified recharges sources for shallow groundwater

Analysis and Results:

Variation of Groundwater Level Data

Groundwater level data of last 30 years of Ghaghar basin were analysed to study the groundwater fluctuation. Water level data show dramatic decline in groundwater level by 12-18 meters during this period. The initial water level trend between 1974 and 1998 is much gentler compared to a steep decline between 1998 and 2010 as observed on time series plots. Southwest part of the study area show rise in groundwater level varying from 10-18 meters during this period.

Isotopic Composition of Rainfall, River and Canal Water

The stable isotope data of precipitation of study area and surrounding 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. Since, 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 from 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. 20 groundwater samples for dating using 14C, CFCs and SF6 has been send to UK for measurement.

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 of groundwater 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. This is reason that groundwater level is raising upwards in southern part of the study area. The hydrochemical analysis of groundwater of study area has been analysed and details results will be present in working group meeting.

There is marked variation in isotopic and chemical composition of groundwater which indicates complex system of recharge. At several places significant recharge from canal has been observed.

Future Plan

- Estimation of volume of water withdrawn due to pumping
- Groundwater Age dating using Tritium, ^{14}C and CFC
- Preparation of final report

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

Title of 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	:	€ 15,000.00
Date of Start	:	September 2012
Date of Completion	:	December 2015

Study Objectives :
The objectives of the study are:

- Investigation of groundwater depletion and dynamic groundwater condition in the study area
- Isotopic and conventional approach to identify groundwater recharge zones and sources
- Change in isotopic and chemical parameters due to long term depletion trend
- Suggesting management measures for groundwater sustainability

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. 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.

Brief Methodology:
1. Collection of rainwater, groundwater and surface water samples and there analysis for stable isotope, radiometric dating and water quality
2. Data interpretation in terms of recharge characteristic, dynamics of aquifer system and use towards sustainability of aquifers
3. Evaluation of changes in water quality and quantity aspects due to extensive exploitation and identifying the parameters (isotopic, chemical and hydrological) that can be used as indicators for the intensive exploitation for the study area
4. Providing remedial cost effective & environmentally suitable strategies along with a conceptual groundwater model for improving the current groundwater situation.

5. Publications of papers
6. Submission of final report to IAEA as per IAEA's TECDOC format

Objectives vis-à-vis Achievements:

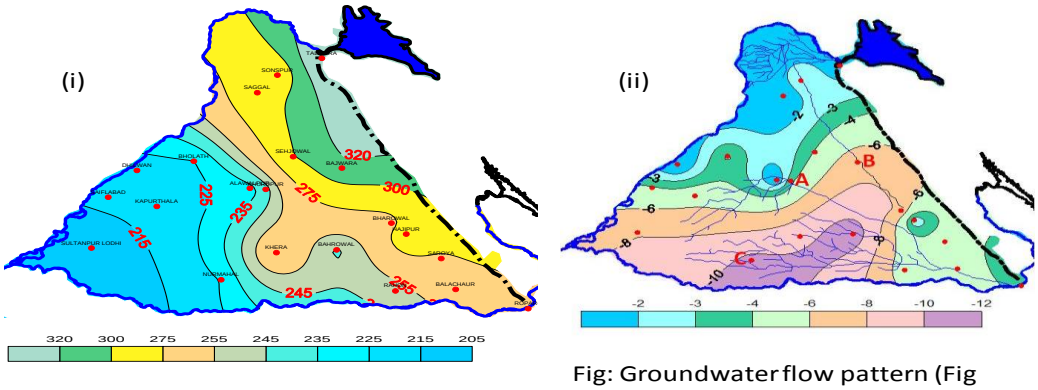
Objectives	Achievements
Investigation the depletion rate of groundwater.	Groundwater fluctuation at annual, seasonal and diurnal scale has been monitored. The water level data has been used to prepare groundwater flow maps.
Investigation of groundwater dynamics and groundwater recharge zones	Used isotope data and groundwater level data to map groundwater flow conditions and recharge & discharge zones.
Change in isotopic and chemical parameters due to long term depletion trend	EC and isotopic composition of groundwater has been monitored for the entire study period. Other than seasonal change no appreciable annual trend is observed.
Groundwater management measures	Suggestions provided
Report writing & publications	Final report will be submitted in Dec. 2015

Results & Analysis:

For long term data analysis, 35 nos of shallow observational wells data for the period 1998 to 2010 was collected from Punjab Water Resources and Environment Directorate and was analyzed to prepare groundwater level contour map and long term fluctuation details.

The rate of groundwater depletion is more in the southern half compared to the northern region. The average rate of groundwater loss turns out to be 4.32km^3/yr. The trend of groundwater level shows major influence from groundwater withdrawal in addition to moderate level of influence from wet and dry years of long term rainfall pattern.

To investigate the daily withdrawal effect, hourly data of groundwater level was monitored for round the year shows high level of diurnal fluctuations especially during the month of November. This indicates major influence of groundwater withdrawal on the falling trend of groundwater levels. To investigate the impact of rainfall variability on groundwater level fluctuation, departure of rainfall against its long term average was compared with groundwater levels. The comparison shows minor fluctuations on the long term depletion trend of groundwater levels as originating from rainfall variation during wet and dry spell years.



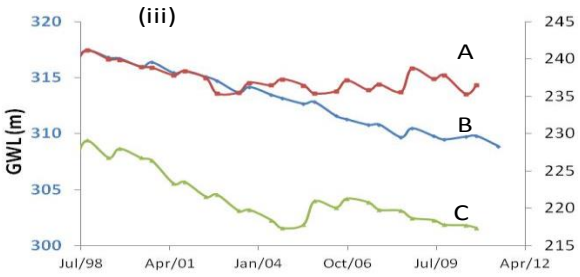


Fig: Groundwater flow pattern (Fig shown in (i)), groundwater fluctuation (fig shown in (ii)) and pattern of groundwater depletion at locations A, B & C (fig shown in (iii)) in the study region. The locations A, B and C are also shown in (ii). All the numbers are in the unit of meters. Negative values in fig (ii) indicate falling water levels. The figures are prepared using, groundwater level data for the period 1998 to 2010. In the figure (iii) the secondary 'Y-axis' is taken for the data at location 'C'.

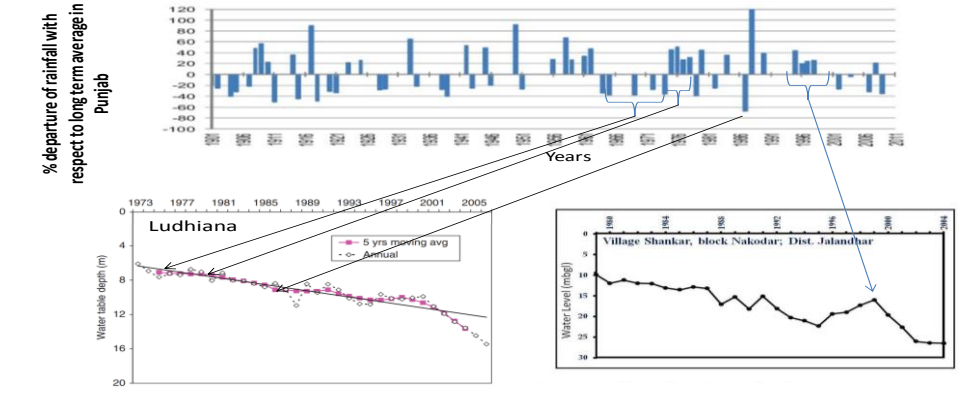


Fig: Influence of rainfall variability on GWL trend

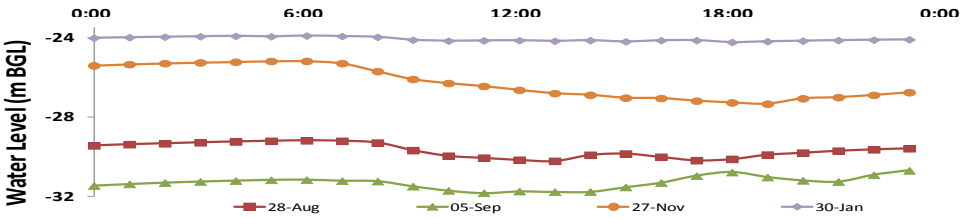


Fig: Influence of daily withdrawal on the diurnal fluctuation in groundwater levels at Saroya

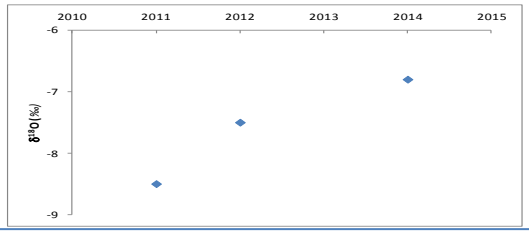


Figure: Systematic enrichment in isotopic composition of groundwater observed at Amritpur village located near the river Beas during 2010 to 2015

The isotopic data at some locations also indicated a systematic enrichment pattern indicating changing groundwater recharge conditions. The isotope data has also been used in mapping the groundwater recharge areas of the region.

Conclusions

- The archival data clearly depicted depletion of surface water and groundwater resource of the region.
- The depletion of groundwater is occurring mainly in southern part of the region and it is at rate ~ 1m/yr. Groundwater from the region is getting depleted at a rate ~ 4.32km^3/yr.
- The deep groundwater in southern region is old and it contains canal infiltrated recharge component that is recharged a few tens of year back (as according to its low tritium content observed in this region).
- The over-exploitation of groundwater and lining of canal perimeter resulted into replacement of canal infiltrated recharge component by more dominant rainfall recharge component in the shallow aquifer.
- The isotope data provides evidence of enhanced groundwater recharge after the upcoming of reservoirs in the Kandi belt during 1980-1995.
- Groundwater in shallow aquifer is 15-48 years and that in deep aquifer is 38-54 years old.
- Since the groundwater is young in the region (atleast over a depth up to 150m) it is possible to artificially recharge the groundwater using appropriate recharge measure technique.
- Since the deeper aquifers are in depleted conditions from June to December when monsoon is active; it provides a good avenue to recharge these depleted aquifer from excess monsoon rainwater and the use of this recharged water in the post monsoon season.
- The isotope techniques found useful in identifying anthropogenically modified groundwater conditions of the region and ways to overcome it.

Future Plan: The study has been completed. Final report will be submitted to IAEA in December, 2015.

10. 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

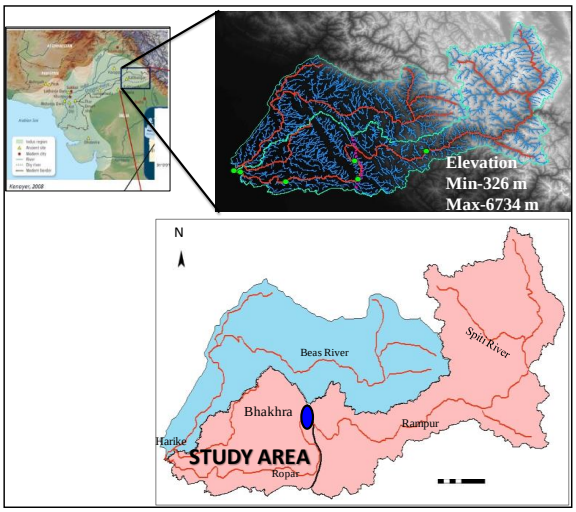
Budget : €15000

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.

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	• Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water • Groundwater dating using tritium • Delineation of flow direction and recharge zones using water level and tritium data • Hydro-chemical analysis of groundwater
Comparative study of recession characteristics of Satluj River with conceptual and isotopic model	• Isotopic technique has been used to separate out different component of hydrograph • Modelling approach has been attempted to separate out the baseflow component of stream discharge • Comparison of both study is under progress
To assess the potential and limitations of the tracer techniques for routine application in hydrological studies	• Assessment of potential of tracer techniques are 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:

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

Isotopic and Chemical 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 (δ^2H) 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 δ^2H -81.6‰ (minimum) to -35.2‰ (maximum).

The $\delta^{18}O$ and δ^2H 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 δ^2H of the data of different depth gives the best fit line (BFL) as:

$\delta^2H = 6.7 * \delta^{18}O - 1.5$ (n = 96, r^2 = 0.98) (< 80 m)
(eq. 5)
$\delta^2H = 7.6 * \delta^{18}O + 4.9$ (n = 76, r^2 = 0.92) (>100 m) (eq. 6)

Generally, shallow groundwater show enriched $\delta^{18}O$ and δ^2H values in the study area. However at few locations depleted value (more than -9‰) are also found due to possible recharge through river/canal. The deep aquifer shows almost similar isotopic composition throughout the study area which resembles the isotopic composition of precipitation.

The groundwater mainly belong to Ca-Mg- HCO_3 type. The Na^+/Cl^- vs Cl^- plot shows increasing Na concentration without any significant change in Cl^- indicates increase in Na^+ mainly due to dissolution of plagioclase as the major source for groundwater chemistry in the study area. The results of water chemistry supports the finding of the isotope.

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 partitioning of stream flow has been carried out using the isotopic modeling techniques. The results as well as their analysis will be presented in details during WG meeting.

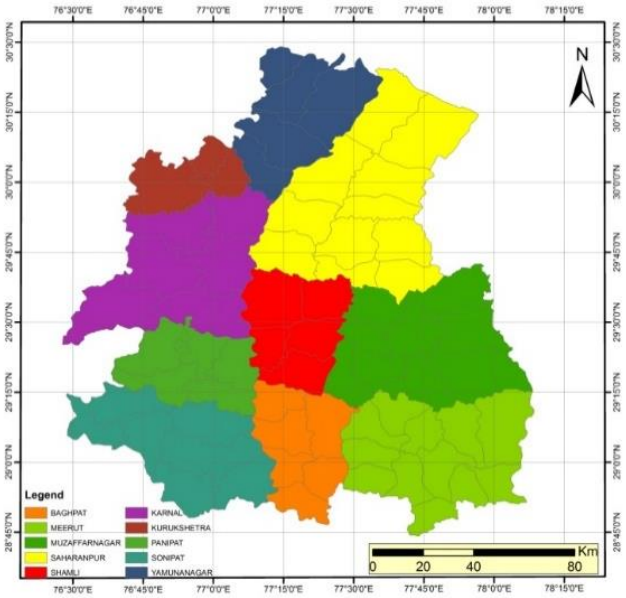
Future Plan

- Isotopic characterization of rain, river and groundwater
- Identification of groundwater discharge and recharge zones to Satluj river.
- Preparation of final report

Working Group is requested to grant extension of the project till March, 2016

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 Team	**:**	Sudhir Kumar (PI), S. P. Rai, Suhas Khobragade, C. K. Jain, P. K. Garg
Funding Agency	:	IAEA, Vienna
Budget	:	€28,500
Duration	**:**	May 2013 to April, 2015
Location Map	**:**	



Study Objectives:

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:

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**.**

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

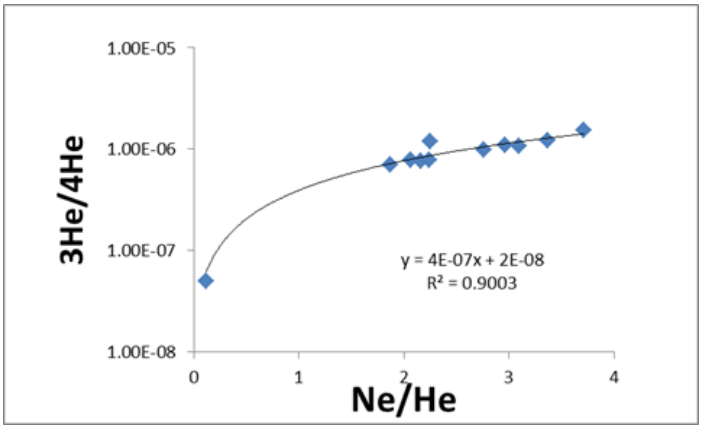
Present Status

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. 28 samples from shallow wells tapping the I^{st} aquifer have also been collected.
3. Analysis of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis is under progress.
4. Carbon-14 and carbon-13 analysis of 14 samples has been completed
5. Noble gas analysis for 12 samples has been completed
6. Thirty One samples locations from Haryana have been collected which includes 10 locations for III^{rd} aquifer, 6 locations from II^{nd} aquifer and 15 locations from I^{st} aquifer
7. Construction of aquifer geometry based on available data / information has been completed

Results:

1. Deeper groundwater (Aquifer-III) in the south western part of UP side is the not being vertically recharged.

2. Oldest ground water in the area is ~ 20 K years
3. Terrigenic helium is from earth crust. Good correlation between Terrigenic Helium and age of groundwater
4. There is a high temperature zone in the south and south western part of UP side study area
5. The results achieved shall be presented during the working group meeting.



Future Plan:

Activity	**Dec'15-Mar'16**
^{14}C samples analysis at IAEA designated laboratory	Dec'15
Interpretation of Data	Jan'16
Interim Report and Discussion of Results during the meeting to be hosted by IAEA	Jan'15-Feb'16
Workshop	Feb'16
Final draft report and discussion on outcome during the meeting to be hosted by IAEA + final report submission	Mar'16

Working Group is requested to grant extension of the project till March, 2016

APPROVED WORK PROGRAMME FOR 2015-2016

S. No.	Study	Team	Duration/ Status
	INTERNAL STUDIES		
1.	Isotopic Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI); C K Jain; SP Rai; SD Khobragade; P. K. Garg; CGWB, Lucknow & Chandigarh)	**2 years** (07/13-06/15) **Continuing Study**
2.	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**
3.	Interaction between groundwater and seawater along the northern part of east coast of India	M. S. Rao (PI), Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16) **Continuing Study**
4.	Isotopic investigation of benchmark Himalayan glaciers.	M. S. Rao (PI) S.P. Rai, Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16) **Continuing Study**
5.	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) **Continuing Study**
6.	Status Report on Rewalsar Lake, Himachal Pradesh	SD Khobragade (PI) Sudhir Kumar, C. K. Jain	**1 year** (04/15 – 03/16) **New Study**
7.	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	SD Khobragade (PI); Sudhir Kumar; Senthil Kumar; Pankaj Garg	**3 year** (04/15 – 03/18) **New Study**
	SPONSORED PROJECTS		
8.	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI); M. S. Rao; Surjeet Singh; S. K. Verma; C. P. Kumar; Sudhir Kumar	**3 years** (06/12-03/16) **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** (09/12-12/15) **Continuing Study**

S. No.	Study	Team	Duration/ Status
10.	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar	**3 years** (10/12-04/16) **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** (05/13-03/16) **Continuing Study**
12	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	S. P. Rai (PI); Sudhir Kumar; Rajesh Singh; S. D. Khobragade; M. Arora; Dr. R. J. Thayyen; P. K. Garg	***To be under taken under NMSHE project***

CONSULTANCY PROJECTS

S. No.	Study	PI	Duration/ Status
1.	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur	Sudhir Kumar	05/13-04/16 **Continuing Study**
2.	Estimation of canal seepage and groundwater recharge using isotopic techniques in the Chajlet block, Moradabad district, Uttar Pradesh	Sudhir Kumar	03/15-02/16 **Continuing Study**
3.	Hydrogeological and isotopic investigations of District Lalitpur and Jhansi of Bundelkhand region	S. P. Rai	05/15-01/16 **New Study**
4.	Hydro-geological study for Gadarwara super thermal power project, Madhya Pradesh	SD Khobragade	**07/15-06/16** **New Study**
5.	Hydro-geological study for Katwa super thermal power project, West Bengal	Sudhir Kumar	**07/15 – 4/16** **New Study**
6.	Hydro-geological study for Darlipali super thermal power project, Odisha	Sudhir Kumar	**9/15 – 8/16** **New Study**
7.	Hydro-geological study for Khargone super thermal power project, Madhya Pradesh	SD Khobragade	**07/15 – 4/16** **New Study**
8.	Hydro-geological and isotopic study for 1x660 MW Harduaganj thermal power project, UP	Sudhir Kumar	**11/15 – 10/16** **New Study**
9	Hydro-geological and isotopic study for 1x660 MW Panki thermal power project, UP	Sudhir Kumar	**12/15 – 11/16** **New Study**

S. No.	Study	PI	Duration/ Status
10	Hydro-geological study for Kudgi super thermal power project, Karnataka	Sudhir Kumar	**11/15 – 10/16 New Study**

WORK PROGRAMME FOR THE YEAR 2015-16

S.No. & Ref. Code	Title	Study Team	Duration
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 Sept. 2015)
2. 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 Sept. 2015)
3. NIH/SWD/NIH/ 13-16	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3 years (April 2013 to March 2016)
4. 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)
5. 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 Sept. 2015)
6. NIH/SWD/NIH/ 14-17	Hydrological modelling of Brahmani Baitarani river basin using eWater Source platform	J.P.Patra Dr. Rakesh Kumar Pankaj Mani	3 years (April 2014 to March 2017)
7. NIH/SWD/NIH/ 14-17	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State	Archana Sarkar Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar N.K. Bhatnagar	2 years (April 2014 to Sept. 2017)
8. NIH/SWD/NIH/ 14-17	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	3 years (May 2014 to March 2017)
9. 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)
10. NIH/SWD/NIH/ 15-16	Generalization and parameter estimation of GEV distribution for flood analysis	Dr. S.K. Singh	1 year (April 2015 to March 2016)
11. NIH/SWD/NIH/ 15-16	Analytical Solution for meeting of two surges or bores	Dr. S.K. Singh	1 year (April 2015 to April 2016)
12. NIH/SWD/NIH/ 15-18	Flood and Sediment studies in Himalayan basin using MIKE-11 Model	Dr. A.K. Lohani	3 years (April 2015 to March 2018)
13. NIH/SWD/NIH/	Snowmelt Runoff Modelling and Study of the Impact of	Dr Achana Sarkar Er. T. Thomas	3 years (April 2015 to

15-18	Climate Change in Sharda River Basin	Dr. Vaibhav Garg	March 2018)
14. NIH/SWD/NIH/ 15-18	Study on effect of climate change on sediment yield to Pong reservoir	Dr A. R. Senthil Kumar Dr. J. V. Tyagi Dr Avinash Agarwal Dr. Suhas Khobragade Dr Manohar Arora	3 years (April 2015 to March 2018)
15. NIH/SWD/NIH/ 15-17	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in Chhattisgarh	Dr. R.P. Pandey Dr. Rakesh Kumar	2 years (April 2015 to March 2017)
16. NIH/SWD/NIH/ 14-17	Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India	Dr. Ashwini Ranade	3 years (Oct. 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 G, 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 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.

The consolidated unit weight of sediment by different methods such as particle size distribution of suspended sediment concentration, hydrographic survey, porosity of uniformly distributed sediment, frequency analysis of unit weight of sediment computed from suspended sediment concentration and empirical formula have been computed. The consolidated sediment volume has been estimated by consolidated unit weight of sediment computed by various methods. The percentage of reservoir capacity lost by different methods for future 25, 50, 75 and 100 years has been computed. The estimation of elevation-area-capacity curve for future periods from consolidated sediment volume is carried out.

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 have been generated with available 276 patterns of historical data. The average probable sediment yield from the ANN ensembles are simulated from 10, 50 and 90 percent probable generated series of rainfall and flow volume. The simulation of sediment yield from data of each ensemble is being carried out with ANN ensembles.

9. Date of completion**: 30 September 2015.**

2. 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 'G' 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 Resiurces Department, Raipur- Data Collection*
   ***Akilesh Verma**, Water Resiurces 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:

Already the MIKE-HYDR Model has been setup for the basin and interim report has been submitted. Data related to existing cropping system and irrigation is not yet provided by the State Water Resources Department. After getting the data the DSS (Plannig) will be applied.

10. Action Plan

Task	Apr. - Sep. 2013	Oct.-Mar. 2013	Apr.- Sep. 2014	Oct. 2013- Mar. 2014	Status
Identification of the study basin					**Identifying the basin in consultation with Chhattisgarh WRD**
Data Collection & Processing					**Completed**
Rainfall-Runoff Modelling using NAM					**Completed**
Implementation of Mike Basin					**Completed**
Scenario generation using DSS(P)					**Data is not yet provided by the State Water Resources Department**

* As some of the data for fine tuning of the model is still required therefore, 3 Months Extension is requested.

Deliverables
Reports and research papers

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

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

2. **Thrust Area under XII five year Plan**: Water Resources Development and Management

3. **Study Group -** Sanjay Kumar, Sc-D, PI
   Sharad Jain, Sc-G, Co-PI

4. **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).

5. **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.

6. **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.

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

8. Action plan and timeline and progress:

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**						

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 and their comments.

(iii) The review comments from experts were discussed in ISO meeting during May 2015 at Tokyo.

(iv) Accordingly, a new draft documents has been prepared incorporating the suggestions/comments of the experts and submitted to BIS/ISO for further review of the member bodies.

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

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

6. 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

7. 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.

8. 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.

9. 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 following comment/recommendation.	
▪ NIL	▪

10. 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.

(e) SWAT and SWAT CUP models have been applied on Chandrabhaga watershed for calibration, verification and prediction periods by developing SWAT inputs files for soil, land use and weather input.

(f) Runoff, sediment transport model CCH1D (National Center for Computational Hydro Science and Engineering) flow model is applied. The flow at each input green node is taken by that estimated by SWAT. The input channel geometry, bed sediment, bank sediment, sediment classification files are created using topography, soil analysis and sample collection and given to the model.

(g) Performance of SWAT and CCH1D models on daily and monthly time series is compared.

Results in brief: All objectives approached.

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	Soil data of UP and Uttarakhand (procured) Spring flow (generated)
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	Report writing

5. 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.

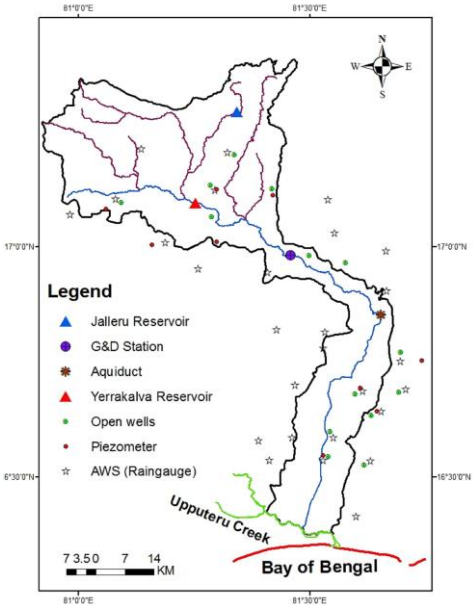


Fig. 1: study area

8. Methodology

SWAT, one of the most recent models developed by the USDA, is 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. 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) Date of commencement of the project: April 2014
(b) Duration of the project: One and half years (Extension for six months i.e. up to March 2016 is required).

10. Progress

The daily rainfall data of the study area have been collected. Soil samples

have been collected from the field and 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 completed. Model set up for the study basin is completed.

The hydrologic design details of Yerrakalva reservoir and other data such as elevation-area-capacity curve, reservoir outflows etc. were required for calibration and validation of the model. These data were provided by reservoir authorities only in November 2015. The reservoir data is now being incorporated in the model in order to calibrate and validate the model with reservoir. Since the process of incorporating reservoir in the model and its calibration and validation would require another 4-5 months, the working Group may consider and approve extension of study period for six months i.e. up to March 2016.

11. 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

6. 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. 'C'; 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

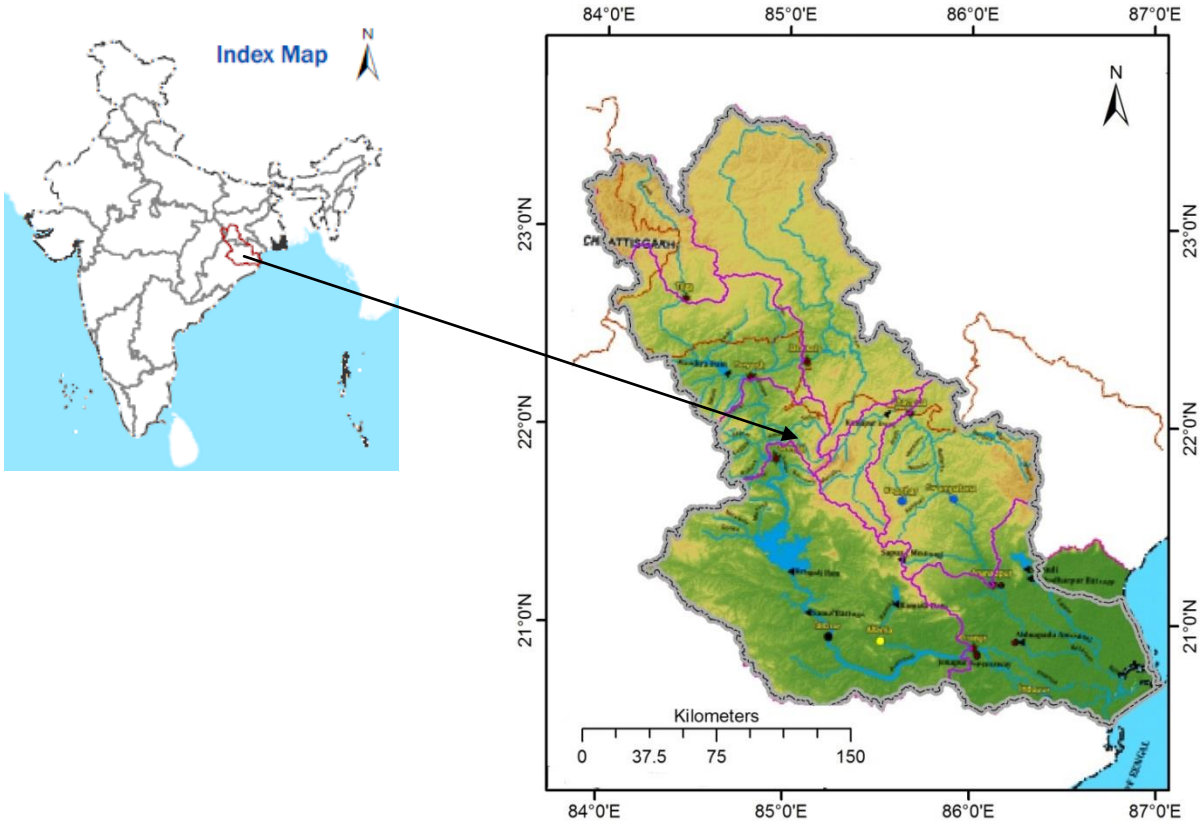


Fig. 1: Location map of study area.

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				Under Progress
6	Calibration and parameter estimation				Under Progress
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 are 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 are used to identify years with near normal, above normal and below normal conditions, using the long term mean of the variables. Further, the daily rainfall data of .25°×.25° obtained from IMD for the period 1901 to 2013 and ET data from Terrestrial Hydrology Group, Princeton

University from 1948 to 2008 are used for rainfall runoff modelling.

Rainfall runoff models are used to derive runoff for a particular sub basin 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 one year 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 also calculated. Both parametric and non parametric trend analysis for some of rainfall and river discharge data has been carried out. During the previous six months the initial rainfall runoff model setup for Brahmani Baitarani river basin using GR4J model in eWater source platform is under progress. The GR4J model is being setup with daily rainfall data of .25°×.25° obtained from IMD and ET data from Terrestrial Hydrology Group, Princeton University. The model calibration is being carried out with gauged sub catchments represented by a small proportion of the basin. Various objective functions are used to for calibration model.

Figure 2 shows comparison of FDC obtained from simulation of streamflow with various objective functions.

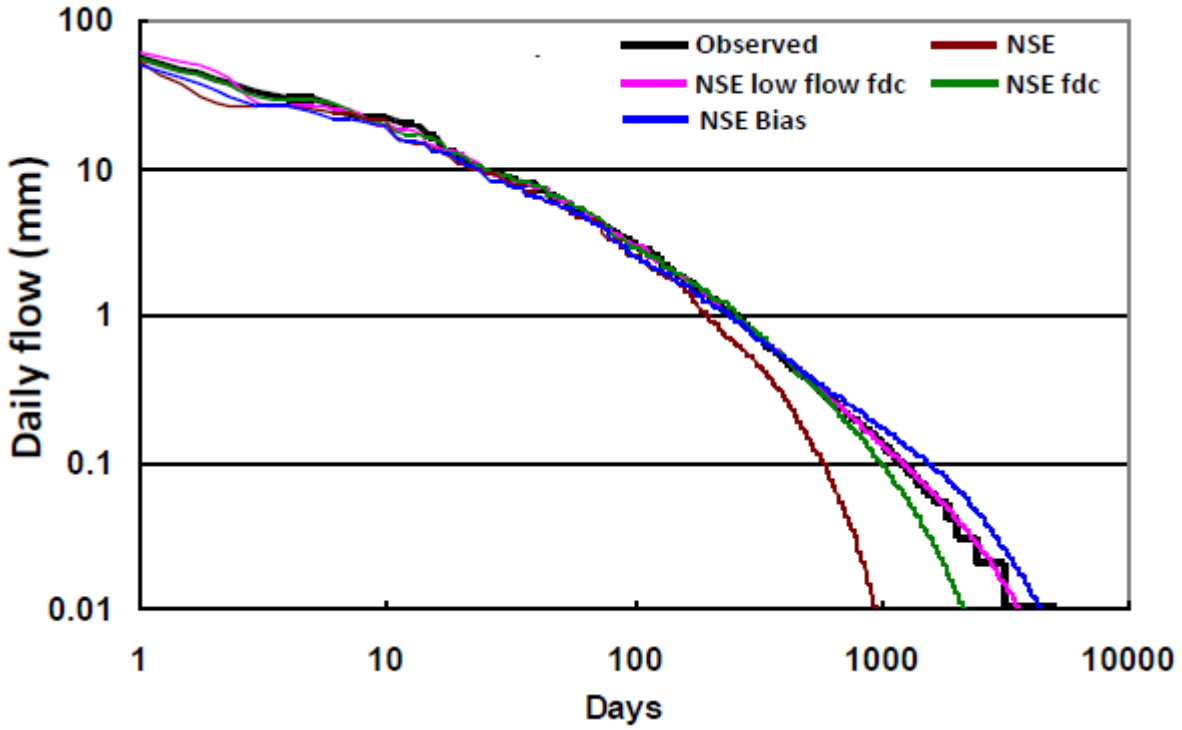


Fig. 2: Observed and simulated flow duration curves for various objective functions.

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.

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

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 D, 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 2017
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-1
2015-16	Trend Analysis of historical rainfall data (different rainfall intensity series)Downloading APHRODITE data.	Downloading of TRMM satellite data and processing of downloaded data	Statistical analysis and comparison of data from different sources	Interpretation of results and preparation of interim-2
2016-17	Comparison of rainfall data from different sources using a hydrological model	Comparison of rainfall data from different sources using a hydrological model	Comparison of rainfall data from different sources using a hydrological model	Preparation & Submission of Final Report

Progress

Objectives	Achievements
April 2014- October 2014	
1. Downloading APHRODITE data **2.** Trend Analysis of historical rainfall data (different rainfall intensity series) 3. Downloading of TRMM satellite data and processing of downloaded data	Completed Completed for five stations with 113 years data. In progress for another five stations Downloading completed, processing in progress

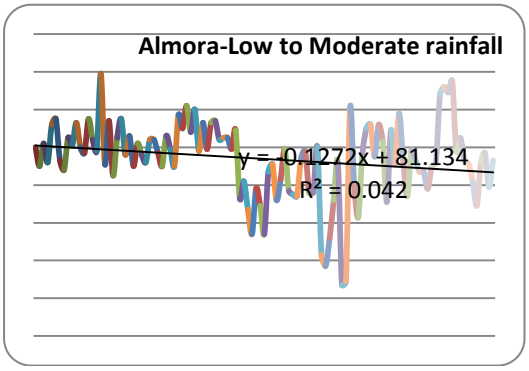
Recommendations/suggestions in previous meetings of working group/TAC/GB: Nil

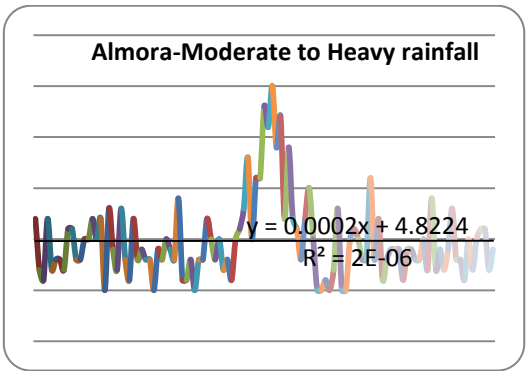
Analysis and results

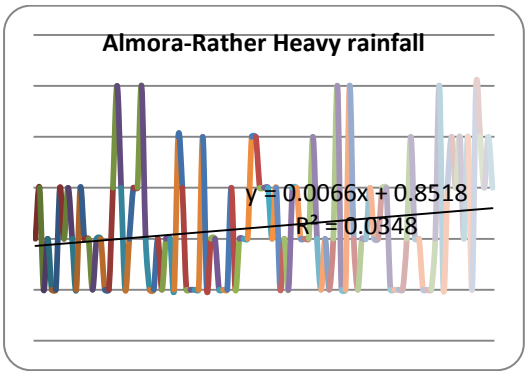
Data Used
Daily rainfall gridded data of 113 years at 10 stations in Uttarakhand.

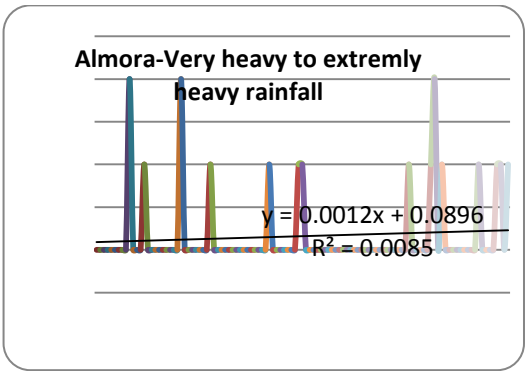
Results
Data processing at five stations namely, Almora, Bageshwar, Haridwar, Joshimath, Munsiyari, Pithoragarh, Rudraprayag, Rudrapur, Tehri, Uttarkashi has been carried

out and annual and monthly rainfall series have been prepared. Besides, four more series of number of various intensity rainfall events (low to moderate, moderate to heavy, rather heavy and very heavy& extremely heavy) series have also been prepared. Trend analysis has been carried out for five stations for five series each. Following graphs show the linear trends in number of events of various intensity of rainfall at Almora station.









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.

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

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

Study Group : Dr Manohar Arora Sc 'D'
Dr Rakesh Kumar Sc 'G'

Role of Team Members:

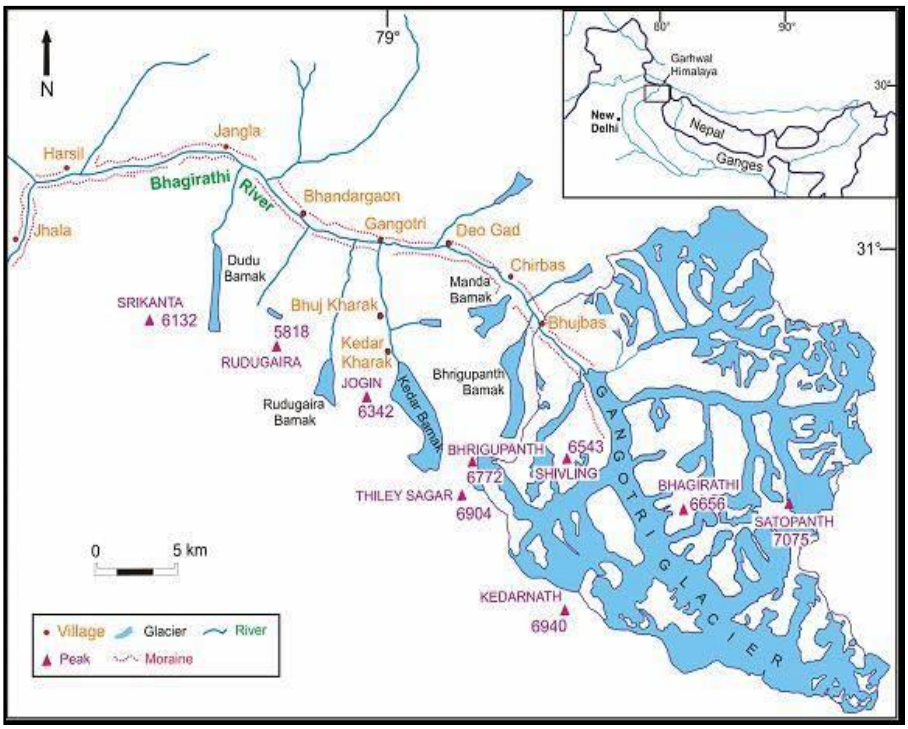
1. **Dr. Manohar Arora, Scientist C& PI:** Conduction field investigations, analyzing data/information, report preparation and overall responsible for the study completion.
2. **Dr Rakesh Kumar, Scientist F &** Co-PI: Guidance in development of methodology, modelling and structuring of report.

Type of Study : Sponsored

Date of start : 01.5. 2014

Scheduled date of completion : 31.03.2017

Location Map:



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 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.

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 2015 have been collected. The team had returned successfully on 10th October 2015.
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 data has been analyzed for the ablation season 2015. It is observed that the Maximum Temperature ranged between 20.5°C to 5.8°C. The standard deviation was 2.5. The Minimum Temperature ranged between 8.6°C to -2.9°C. The standard deviation was 3.0. The Mean Temperature varied between 14.4°C to 2.0°C. The standard deviation was 2.3. The total rainfall observed was 263.2 mm and the maximum rainfall was 55.0mm. The discharge varied between 183.3 m^3/s to 14.5m^3/s. The mean suspended sediment concentration was 1016.8 mg/l and the suspended sediment load was 7033.5 tonnes. The melt water storage and drainage characteristics for this season is under progress. progress.

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.

9. **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 C, 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 are 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 empirical, MLR and the best model developed by soft computing techniques to simulate the evaporation from historical values of rainfall, maximum and minimum temperature and humidity at the site are used to generate the evaporation from the generated values of rainfall, maximum and minimum temperature and humidity for different climatic scenarios as mentioned above.

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. Meteorological data have been categorized in five series such as pre

monsoon, monsoon, post monsoon, winter and annual. The characteristics of Meteorological data are studied in detail to finalize the significant independent variables to model the evaporation. The empirical method, modified Penman method, is used to compute the evaporation from the available data. An ANN model for simulating evaporation has been developed using Meteorological data such as rainfall, maximum temperature, minimum temperature and humidity as input data. Results of the different combinations of ANN model are analyzed based on the performance indices. The ANN model with structure 4-4-1 is best among all the structure, because the performance of the structure in terms of all the statistical parameters is best among all ANN structures. The MLR with the same data considered in the development of ANN model is developed and compared with the performance of ANN model. Future scenarios are being downscaled from the GCM output.

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

10. PROJECT REFERENCE CODE: NIH/SWD/NIH/15-16

Title of the study: **Generalization and parameter estimation of GEV distribution for flood analysis Specific application on Indian data (Research Study)**

Study group	Sushil K. Singh**,** Scientist F
Date of start of study	a. 01 April 2015 ; b. 01April 2016
Duration and scheduled date of completion of study	a. 01 Year; 31 March 2016 b. 06 months; 30 September 2016
Type of study	Internal

Objectives of study

1. To develop a possible generalization of GEV (Generalized extreme value) distribiution and propose both simple and complex parameter estimation of this distribution.
2. To illustrate and demonstrate the practical application of the above GEV on measured data (the published International data and the Indian data available/collected at NIH).

Statement of problem and brief methodology

The GEV distribution as is widely used has two different forms (Type 2 and Type 3) as used in flood frequency analysis. The parameters of Type 2 have generally been estimated using graphical or probability weighted moments for flood frequency analysis considering the reduced variate to be positive.

The objective is intended to possibly unify both type 2 and type 3 GEV distributions in a single GEV and suggest both a simple and optimization method for estimation of its parameters with its illustration on measured/published data (the published International data and the Indian data available/collected at NIH).

Achievement/progress:

The analytical/mathematical part of the developing the intended unified distribution is possible based on pertinent intensive review of previous developments and techniques that can be applied for the unification. The analytical development is in progress with a possible positive outcome.

The developed analytical model is intended to be applied on the published International data and the Indian data available/collected at NIH.

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 with illustrative application on the published international data and the Indian data available/collected at NIH.

11. PROJECT REFERENCE CODE: NIH/SWD/NIH/15-16

Title of the study: Analytical Solution for meeting of two surges or bores

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

Date of start of study 01 April 2015

Duration and scheduled date of completion of study 01 Year; 31 March 2016

Type of study Internal

Objectives of study

1. To develop analytical equations/solutions for two surges or bores in rectangular channel avoiding the trial and error solution, with systematic treatment of surges.
2. To illustrate the practical application of the developed analytical equation using worked-out/ measured-data examples.

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 the case of two surges or bores travelling from opposite direction, analytical results yielding direct solution is of help to users as it will avoid iterative solution.

The objective is intended to be accomplished by analytically solving the required equation for the two resulting surges in a channel and illustrating the ease in application using the available data/examples with a comparison with existing methods.

Achievement/progress:

The analytical development is in progress with a possible positive outcome.
The developed analytical model is intended to be applied on the available data with with a comparison with existing methods.

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 with illustrative of ease in application in comparison to existing methods.

12. PROJECT REFERENCE CODE: NIH/SWD/NIH/15-18

1. Title of the Project: Flood and Sediment studies in Himalayan basin using MIKE-11 Model

2. Thrust Area under XII five year Plan
Flood & Sediment Modelling

3. Project team:

a) Project Investigator: Dr. A.K. Lohani, Scientist G
b) Project Co-Investigator(s): Dr. S.K. Jain, Scientist G

4. Objectives

To model the floods generated due to cloud burst events.
To develop discharge-sediment relationship.
To assess sediment dynamics in the river system.

5. Present state-of-art

In upper Ganga basin, several water resources projects are under operation and many more are coming up to harness these resources. These projects are of considerable national and local importance in terms of hydropower generation, irrigation, flood control and subsequent socio-economic development of the region. In the recent past various cloud burst events have been observed in the Himalayan region. Therefore, it is important to analyse the cloud burst generated floods in the basin. Furthermore, the Himalayan rivers carry very high sediment load. The waters of the Ganga carry one of the highest sediment loads anywhere in the world. Therefore, keeping in view the up coming projects and development in the Himalayan region modeling of the sediment dynamics in a river system is need of the day.

6. Methodology

Steps of the methodology are:

- Analysis of available precipitation data for different return period for the identified sub basin.
- Historical study of cloud bursts in the Himalayan Region.
- Study of phenomenon of cloud bursts
- Quantification of cloud burst phenomenon into flood hydrograph at the critical section in the river stream.
- Flood routing of cloud burst flood.
- Development of MIKE-11 based sediment model to assess the sediment dynamics of the river system.

7. Analysis and Results:

Collection of data/information related to cloud burst and sediment is in progress. Contacted various Central and State organizations working in the area for the required data/ information. Model for flood modeling is being setup for the hypothetical cases. MIKE-Hydro-River software with rainfall-runoff module, hydrodynamic module, Flood module and Sediment module etc. is required for the study.

8. Research outcome from the project

The research outcome will be in the form of technical report, research papers. Development of methodology for the cloud burse flood modeling and sediment modeling.

9. Work Schedule:

Sl. No.	Work Element	2015-16	2016-17	2017-18
1	Data Collection	In progress		
2	Procurement of Mike- Software	In progress		
3	Analysis of available precipitation data for different return period for the identified sub basin			
	Historical study of cloud bursts in the Himalayan region.	In progress		
	Quantification of cloud burst phenomenon into flood hydrograph at the critical section in the river stream			
	Flood routing of cloud burst flood.			
	Development of MIKE-11 based sediment model to assess the sediment dynamics of the river system.			
	Report writing			

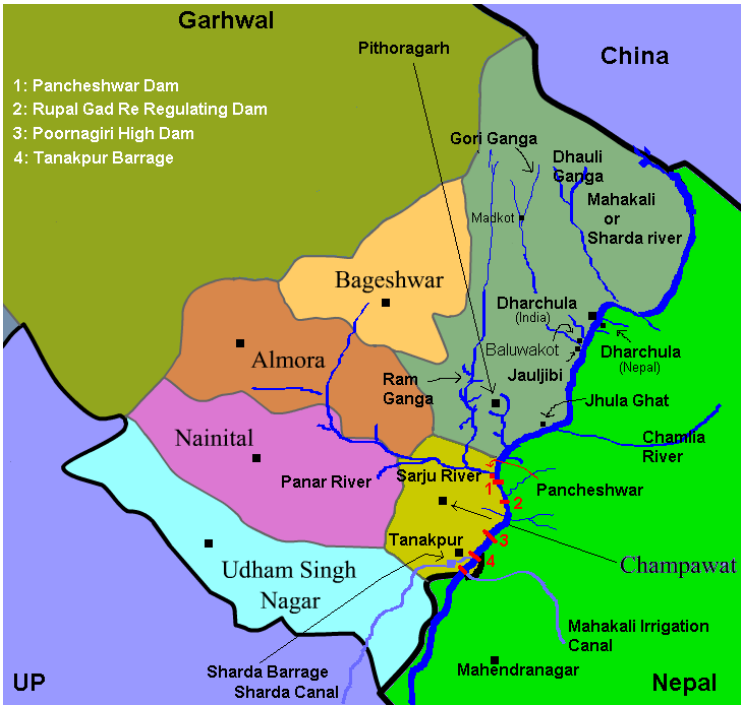
13. PROJECT REFERENCE CODE: NIH/SWD/NIH/15-18

Title of the study : Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin

Name of the PI & CO-PI:

Dr Archana Sarkar, Sc 'D', SWHD (PI)
Er. T. Thomas, Sc D, Regional Centre, Bhopal
Dr. Vaibhav Garg, Sc C, IIRS, Dehradun
Sh. N.K. Bhatnagar, PRA, SWHD

Type of study : Internal
Date of start : April 2015
Scheduled date of completion: 1 March 2018
Study area



The Sharda Valley in Uttrakhand has a vast potential for Water Resources Development, which was not tapped at all during the initial three decades of planned development. The region is mythological abode of Gods; the pilgrim route to Holy Mansarover passes along the Sarda Valley. The river Sharda (or Kali) form the international boundary between India and Nepal, towards the north, from a point called Bramhadeo, about 5 km upstream of Tanakpur. River Sharda originates in the region of Higher Himalayas, near Indo-Tibetan border, from the Glacier of Zaskara range, at about 5250 M. In the upper reaches, in the hills, it is called Mahakali. The river emerges into plains at Bramhadeo and it is called Sharda. The study area extends between 29°0'–30°38'N and 79°28 – 81°7'E covering an area of about 15280 Sqkm, with elevation ranging from 250 to 7000m above msl. About 1732 Sqkm of the total area of the basin is under glacier landscape. The Main River generally flows in north-south direction and is met with by a number of major

tributaries from Indian side, namely, Dhauliganga, Goriganga, Sarju and Ladhia. The major tributary from the Nepal side is Chameliya. The Sharda river finally joins the Ghaghra (Karnali) River as its right-bank tributary in Uttar Pradesh. The Sharda Valley in Uttrakhand has a vast potential for Water Resources Development. The Tanakpur Hydroelectric Project (120MW) was commissioned in 1992 by the NHPC with a barrage on the Sharda River near the town of Tanakpur in the district of Champawat. Mahakali (Sharda in India) is one of the five major river basins of Nepal which is shared with India and of which about 34 per cent of total basin area lies in Nepal. The hydroelectric potential of the valley on the Indian side of the river as assessed by UP Irrigation Department is over 3000 MW; and the power potential of the main Sharda river is assessed as 2000 MW. Therefore, accurate estimation of the basin runoff (including snowmelt runoff) is of extreme importance.

Objectives of the study

i. Preparation of basin maps including DEM and estimation of snow cover area using remote sensing data

ii. Calibration of conceptual snowmelt runoff models namely, SRM and SNOWMOD for Sharda River basin upto Tanakpur.

iii. Development and training of black-box models (ANN models) for simulation of runoff including snowmelt runoff of the Sharda River basin upto Tanakpur.

iv. Inter-comparison of various models.

v. Investigation of the impact of likely future changes in climate on stream flow using downscaled GCM scenarios in the study area.

Statement of the problem

Rainfall-runoff models are of prime importance in the decision making process of water resources planning, design, development and management activities. Such models are used, for example, in the design and operation of hydraulic structures, for flood forecasting, and for evaluating possible impact of land use land cover changes as well as climate changes over a catchment. However, due to the interrelated character of driving factors, i.e., physiographic and climatic factors, the rainfall-runoff process becomes highly complex to understand and also extremely difficult to model. Further, in Himalayan region, like the Sharda River, snowmelt is a governing factor for runoff generation. So, for snow-fed basins, snowmelt runoff component is also required to be incorporated in the modelling approach. It is, therefore required to apply a suitable methodology for modelling the runoff in the Sharda river basin.

Potential climate change and its unfavourable impacts on hydrologic systems pose a threat to water resources throughout the world. The effect of climate on hydrology in tropical Asia has many facets. The Himalayas, which act as a mountain barrier on the earth, where polar, tropical and Mediterranean influences interact, play an important role in maintaining and controlling the monsoon system over the Asian continent. In the Himalayas, the storage of precipitation in the form of snow and ice

(in glaciers) over a long period provides a large water reservoir that regulates annual water distribution. The majority of rivers originating in the Himalayas have their upper catchments in snow covered areas and flow through steep mountains. If there is any climatic variability in the Himalayas, the impacts could be felt in regions downstream. Therefore, besides reasonably accurate estimation of the runoff, there is an imperative need to study the impact of climate change on the runoff regime of the Sharda basin in view of its huge water resources potential including uses for hydropower, irrigation etc.

Approved action plan

S. No.	Work Element	First Year				Second Year				Third Year			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
1	Collection of information and Hydro-meteorological Data												
2	Preparation of base maps												
3	Downloading MODerate resolution Image Spectral radiometer (MODIS) snowcover data products for for the study area												
4	Analysis and interpretation of weekly MODIS snowcover data and preparation of snow cover maps												
5	**Preparation & Submission of Interim Report-I**												
6	Input data preparation for SRM Model												
7	Calibration and Validation of SRM Model												
8	Input data preparation for SNOWMOD Model												
9	Calibration and Validation of SNOWMOD Model												
10	Input data preparation for ANN Models												
11	Training and Validation of ANN Models												
12	Preparation & Submission of **Interim Report-II**												
13	Inter-comparison of Models												
14	Downscaling of GCM outputs for the study basin												
15	Preparation of Input data for conceptual model for changed												

	climate scenarios												
16	Simulation of conceptual snowmelt runoff model with changed climate scenarios												
17	Preparation & Submission of Final Report												

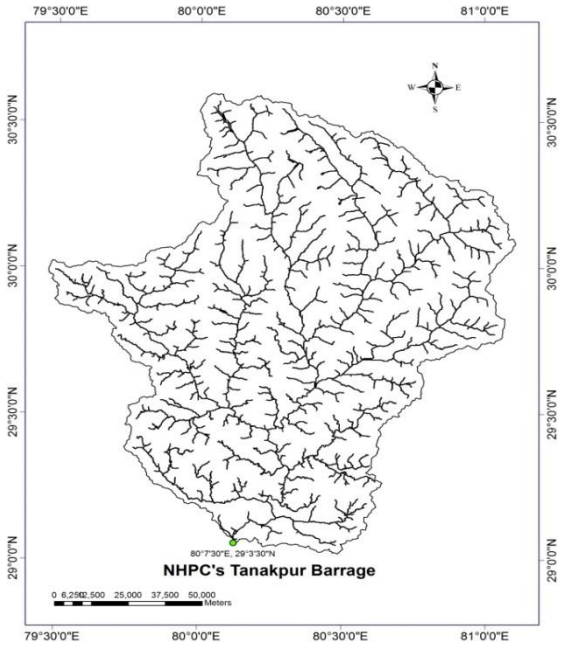
Progress

Objectives	Achievements
April 2015- October 2015	
1. Collection of information and Hydro-meteorological Data 2. Preparation of base maps	Partially Completed Completed

Analysis and results

Data Used: SRTM DEM data and SOI toposheets

Results : Various base maps (drainage and DEM) have been prepared and further processing is being carried out



Expected adopters : State Water Resources Dept and other agencies.

Deliverables: Research papers and report

Data procured and/generated during the study: **N**il

Future plan: As per the approved action plan.

14. PROJECT REFERENCE CODE: NIH/SWD/NIH/15-18

1. Title of the study: Study on effect of climate change on sediment yield to Pong reservoir

2. Study Group:

Dr. A. R. Senthil kumar Sc E, SWHD
Dr. J. V. Tyagi, Sc "G", SWHD
Dr Avinash Agarwal, Sc "G", SWHD
Dr. Suhas Khobragade, Sc "E", HID
Dr Manohar Arora, Sc "D", SWHD

3. Date of start: 1 April 2015
4. Duration of the study: 3 Years
5. Whether externally funded or not: No
6. Objectives of the study:

i. To model sediment yield at Pong dam.
ii. To investigate the impact of likely future changes in climate on sediment yield up to Pong dam using future climatic scenarios.
iii. To assess the life of the reservoir for the likely sediment yield under the projected different climatic scenarios.

7. Brief methodology:

Sediment yield model

The sediment yield up to Pong reservoir is modeled by Soil and Water Assessment Tool (SWAT) with the information about weather, soil properties, topography, vegetation and land management practices occurring in the watershed.

Climate Scenarios

The different scenarios of climatic conditions such as RCP2.6 and RCP8.5 are obtained from CMIP5 models available from different institutes.

Computation of sediment yield under different scenarios

The parameters of the SWAT are calibrated using the historical hydro-meteorological data. The future sediment yield is simulated using SWAT with the data of different climatic scenarios. The impact of likely future changes in climate on stream sediment yield up to Pong is analyzed by the output of SWAT for future climate scenarios.

Revision of elevation-area-capacity table

The projected sediment volume for future periods is distributed in the reservoir by empirical-area reduction method to find out the revised elevation-area-capacity table.

8. Results achieved with progress/present status

Literatures related to downscaling of CGMs have been reviewed from renowned journals. The data of land use, soil type, rainfall, wind velocity, relative humidity, temperature, solar radiation, potential evaporation, runoff and sediment yield at outlet, runoff and sediment inflow to storage structures located in the catchment and elevation-area curve of the storage structures in the catchment are required for setting up of SWAT model to simulate the sediment yield. The required data are being collected from the project authorities.

9. **Expected date of completion: 31 March 2018**

15. PROJECT REFERENCE CODE: NIH/SWD/NIH/15-17

Title of the study: **study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath basin in Chhattisgarh**

Project team

Name of PI: **Dr. R.P. Pandey, Scientist F**; Surface Water Div., NIH Roorkee

Name of Co-PI: Dr. Rakesh Kumar, Scientist G, Surface Water Div., NIH Roorkee

Type of study: 1305000 (**Internally Funded)**
Project Duration: **2-years**
Date of start: **April 2015**
Scheduled Date of Completion: **March. 2017**

OBJECTIVES OF THE STUDY:

The primary objectives in this study are as follows:

(1) To analyse long-term rainfall and streamflow data for assessment of regional drought characteristics
(2) To assess the climatic variability in terms of long term trend in climatic variables.
(3) To assess long-term changes in evapotranspiration and sensitivity analysis of ET to different climatic variables.
(4) Estimation of Crop Water Requirement (CWR) and net irrigation requirement (NIR) using suitable method.
(5) To analysis Long Term Trend in NIR to estimate the change in total Irrigation Water Demand (IWD).

Study Area : Seonath Basin in the Chhattisgarh State

The study selected for this study is Seonath River Basin in the state of Chattisgarh. The Seonath River is the longest tributary of the Mahanadi River basin draining three districts of Chhattisgarh namely Durg, Rajandgaon and Bilaspur. 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 drainage area of the Seonath river basin is 30,860 Sq km. The mean annual rainfall in the basin varies from 1005 mm to 1255 mm. Seonath river basin comprises 25% of the upper catchment of the Mahanadi basin.

The study area (Seonath river basin) falling in Chhattisgarh State faces frequent droughts. Most of the tributaries of Seonath River get dried by mid-winter season and both rural and urban areas are subjected to severe water crisis during the summer season due to erratic and skewed nature of rainfall. Multipurpose water demand has increased with growth in population and the pattern of water availability and utilization has also changed with time. Sustainability has become a challenging issue in water resources development and management.

Proposed Methodology

For determination in variability of climatic factors and the long term changes in IWD, the methodology would include the following:

- The determination the monotonic linear trends in metrological time series (Temperature, Rainfall, Relative Humidity, Wind Speed and Sunshine Hours) using the Mann Kendall's test.
- Estimation of the slopes of trend lines of metrological variables using the Theil–Sen's slope estimator.
- Determination of the step change/ detect the abrupt changes in the time series using cumulative deviation test and distribution free CUSUM test.
- Determination of the percentage variability of metrological series by Coefficient of Variation (CV) over entire Seonath river basin.
- Estimation of ET using suitable method and the application of the Partial Relative Correlation Method to investigate the correlation between ETo and meteorological variables.
- Estimation of CWR and NIR and subsequently assessment of changes in the total Irrigation Water Demand in different seasons.
- Long term Trend Analysis of Net Irrigation Requirement and determination of trend in ET and NIR using Mann Kendall's test and Thiel's Sen's Slope Estimator will be use to estimate the trend magnitude.

  Thus the study will lead to assess changes in irrigation water demand over past 50-years in the context of long term changes in climatic variables.

Progress of Work

(i) **Collection of information and Hydro-meteorological Data**

The daily meteorological data [Rainfall, Temperature (maximum, minimum and mean)] of 24 stations have been collected from IMD, Pune for 51 years (1960-2010). Observed data on wind speed and relative humidity is available only for eight stations. The pan evaporation data is available only for one station viz., Raipur. The location of the stations is shown in Figure 1 Also, the discharge data for the same period at the single outlet namely Nandghat, has been obtained from State Data Centre, Department of Water Resources, Raipur (Chhattisgarh).

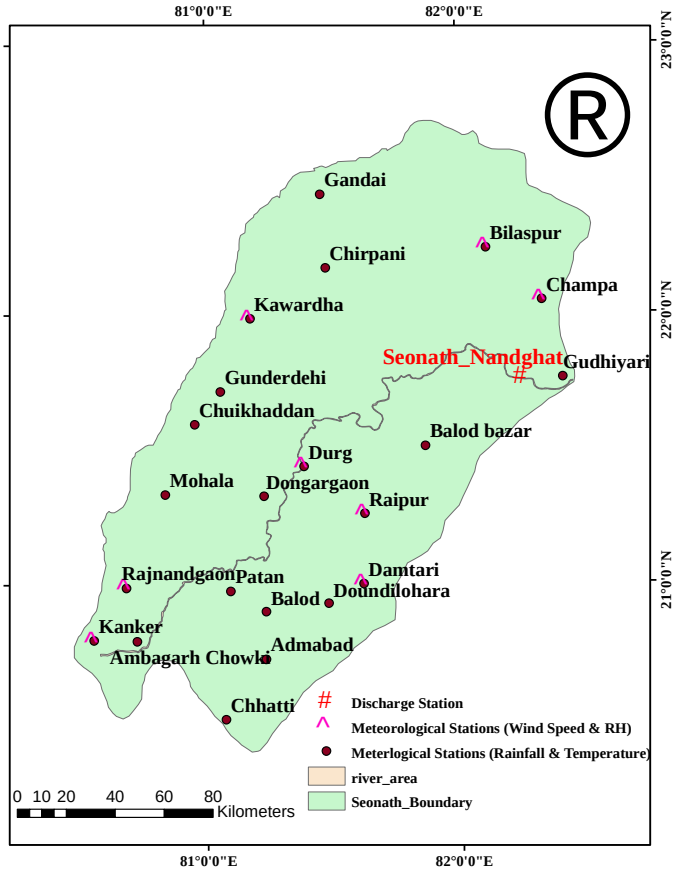
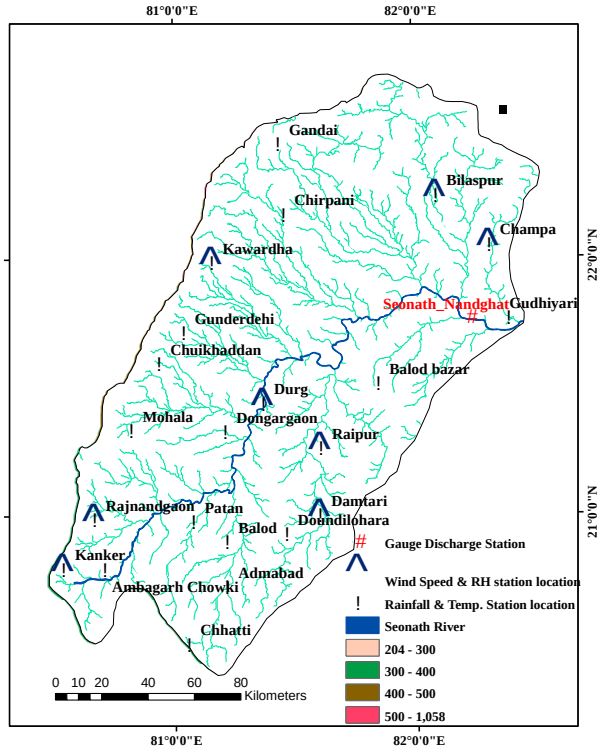


Figure 1 Location of Meteorological stations in Seonath basin

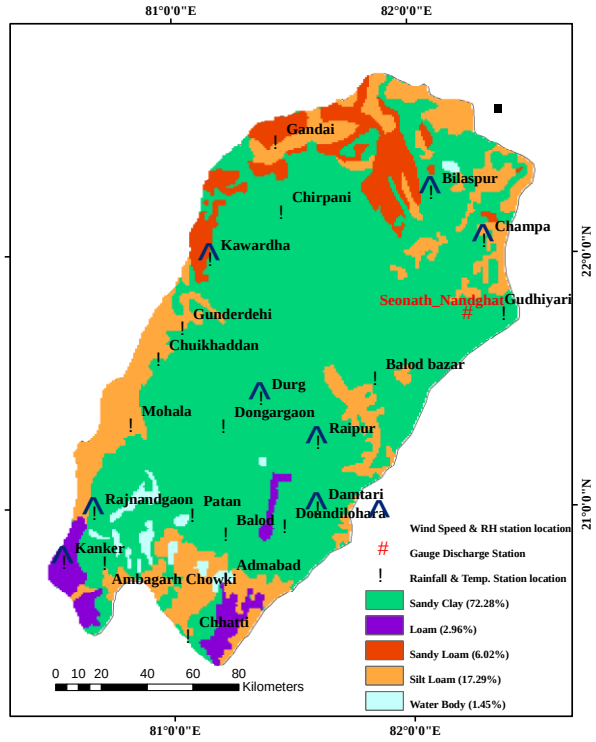
(ii) **Preparation of Base maps *(Digital Elevation Model (DEM), Soil Map, Land Use Map and District Map etc*.):**

The Shuttle Radar Topography Mission (SRTM) data are digital elevation data on a horizontal grid spacing of 1 arc seconds (approximately 30m resolution). Further the downloaded images have been used for the preparation of digital elevation model (DEM) and drainage network using Arc GIS software version 9.3. The data is acquired from the URL: (http://glcfapp.glcf.umd.edu:8080/esdi/) for basin delineation and drainage network extraction. The DEM of the basin is illustrated in Figure 2.

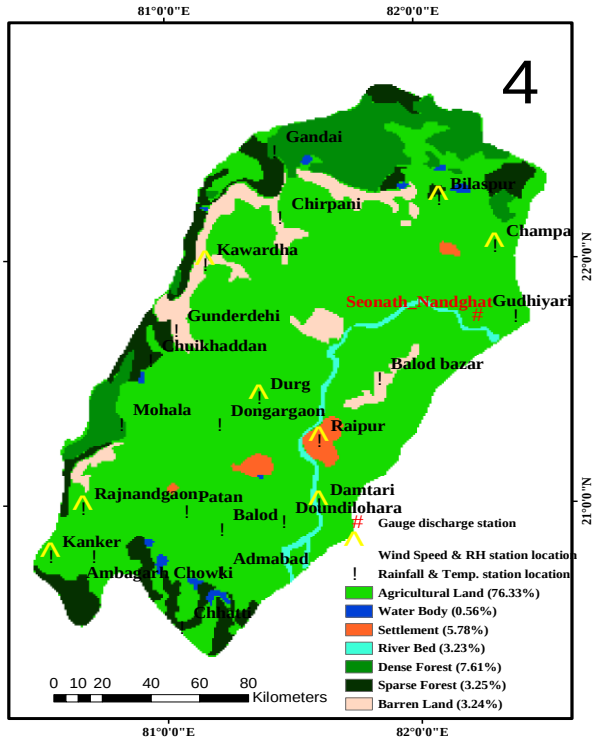
The composite map (Figure 1) has been prepared to illustrate the location of different meteorological stations located within Seonath River Basin. Figure 2a and 2b present the DEM maps showing elevation of different stations and the diatribution of soils. The Gandai station (in kawardha district) is located at highest elevation (525 m) whereas Gudhiyari station (in Durg district) is located at lowest elevation (226 m). The soil type is almost same at all the locations i.e, sandy clay except few locations viz, Mohala, Gandai and Admabad which have silty loam type soil (Figure 2b, & col.5 in Table 1). The main soil types found in the basin are sandy clay covering 72.28% of the basin area followed by silt loam 17.29% of the basin area (Figure 2b). Sandy clay predominates in the middle whereas loam and silt loam are found in lower reaches of the drainage channels and in the upstream channel sandy loam are also found. The major land use of the basin is for agriculture except in Raipur district which shows major settlement; therefore the basin is described as an agriculture basin (Figure 2c, col.4 in Table 1).



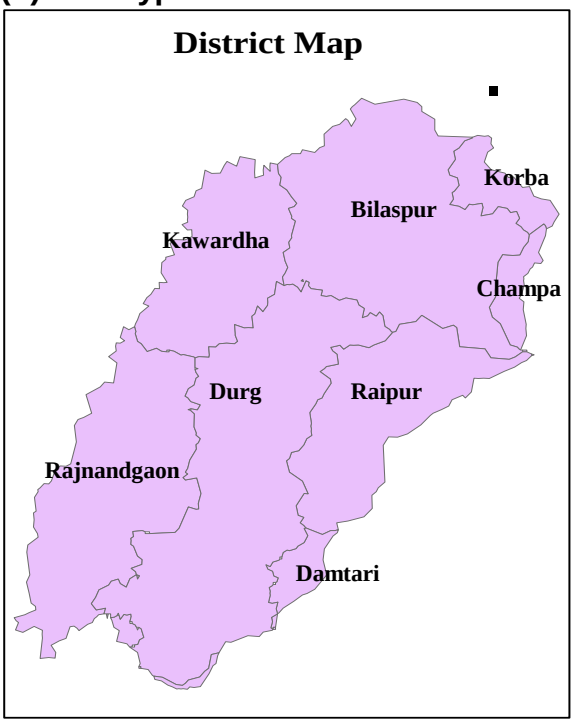
(a) DEM and Drainage network



(b) Soil Type



(c) Land Use/Cover Map



(d) District Map

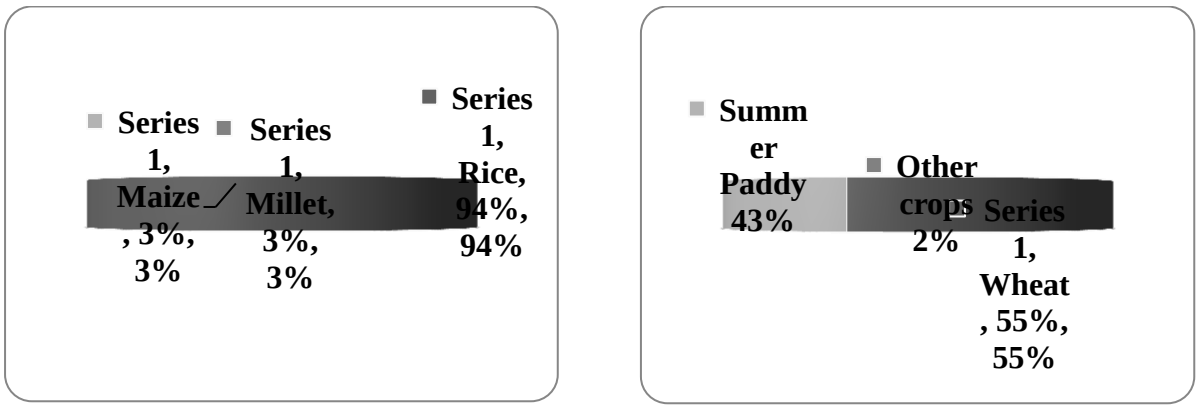
Figure 2: Physical characteristics at locations of meteorological stations in Seonath asin

Table 1: Characteristics of Meteorological Stations located in Seonath river basin

Station	District	Area (Sq.km)	Land Use	Soil Type	Elevation
Column 1	***Column 2***	***Column 3***	***Column 4***	***Column 5***	***Column 6***
Ambagarh Chowki	Rajnandgaon	5688.63	Agricultural Land	Sandy Clay	337
Chuikhaddan				Sandy Clay	337
Dongargaon				Sandy Clay	255
Mohala				***Silt Loam***	330
Rajnandgaon				Sandy Clay	316
Balod Bazar	Raipur	3877.25	Settlement and Barren land	Sandy Clay	254
Raipur				Sandy Clay	287
Simga				Sandy Clay	285
Chhatti	Dhamtari	533.15	Agricultural Land	Sandy Clay	430
Damtari				Sandy Clay	326
Chirapani	Kawardha	3525.13	Agricultural Land and Dense Forest	Sandy Clay	353
Kawardha				Sandy Clay	357
Gandai				***Silt Loam***	525
Doundi Lohara	Durg	8474.67	Agricultural Land and Barren Land	Sandy Clay	317
Durg				Sandy Clay	288
Patan				Sandy Clay	332
Admabad				***Silt Loam***	314
Balod				Sandy Clay	324
Gudhiyari					226
Gondly				Sandy Clay	312
Dongaragaon				Sandy Clay	324
Gunderdehi				Sandy Clay	313
Bilaspur	Bilaspur	6916.18	Agricultural Land	Sandy Clay	272
Champa	Jhanjgir-Champa	553.2	Agricultural Land	Sandy Clay	232

Agriculture is the main occupation of people in this sub-basin. About 76% of the basin area is under cultivation. There are two cropping seasons namely, monsoon (kharif) season from mid-June to October and post-monsoon (rabi) season from November to middle of April. Rice is the major crop of monsoon season covering 94% of the cultivated basin area (Figure 3a). During rabi season, wheat, summer paddy, pulses and oilseed are grown. The kharif rice, wheat and summer paddy are the main crops covering an area of about 22679 sq. km i.e., 98% of the basin cultivated area (Figure 3b).

Further work is in progress.



(a) Kharif Season Crops (b) Rabi Season Crops

Figure 3: Crops and cropping pattern of Seonath river basin (Source: Directorate of Economics and Statistics, Chhattisgarh)

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

Title of Study: Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India

Study Group: Dr. Ashwini Ranade, Scientist 'C'
(Principal Investigator)

Role of Team members: As PI, overall responsibility of the completion of the project Successfully (e.g.) Literature Survey, Data collection and processing, Analysis, Preparation of report

Type of Study: Sponsored Research

Sponsoring Agency: Science and Engineering Research Board (SERB), Department of Science and Technology, New Delhi

Budget sanctioned: **12.6 lakh**

Date of Commencement: 17 October 2014

Scheduled date of completion: 31 March 2017

Study Area: The proposed work is for Asia-pacific monsoonal regime (25^0-150^0E; 25^0S-150^0N) with more emphasis has been given for the Indian subcontinent**.**

Statement of the problem:

Asia-Pacific summer monsoon is a thermally driven circulation. Heterogeneous changes in global tropospheric temperatures from last few decades are observed to make spatio-temporal changes in global rainfall distribution. In the era of global warming, despite of rising global surface temperature, most part of Indian subcontinent (Indo-Gangetic plains and central India) is experiencing weaker monsoon and an increase in occurrences of extreme rain events (EREs). An index will be developed to delineate the global monsoonal regime and commencement and cessation of monsoon circulation. Dates of the start and end of the monsoonal rains across Asia-pacific region will be determined by using objective criteria. Influence of global temperature changes on the characteristics of rainfall occurrences (start, end, intensity, frequency, location and duration) will be studied thoroughly. Round-the-year real-time global monitoring system will be developed in order to predict weathers across Indian subcontinent.

Objectives:

1. To investigate underlying mechanism of intensification and weakening of Asia-Pacific monsoon circulation intensity in the backdrop of heterogeneous global temperature change.
2. Determination of commencement and cessation dates of monsoon circulation and start and finish of monsoonal rains.
3. Construction of representative index for intensity of Asia-Pacific monsoon circulation.

4. To understand structure of the monsoon circulation associated with large-scale extreme rain events over and across India.

Approved Action Plan:

Work Plan	Period in months							
	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-36
Literature Survey and JRF appointment	→	→	→	→				
Collection of global dataset		→	→	→	→	→	→	
Study of asymmetry in global tropospheric thermal structure		→	→	→				
Development of round-the-year real-time monitoring system			→	→	→	→	→	
Development of Asia-pacific monsoon intensity index				→	→	→		
Development of objective criterion for the onset and withdrawal dates					→	→	→	
Relationship between circulation parameters and large-scale extreme rain events						→	→	→

Objectives vis a vis Achievements:

Objectives	Achievements
To investigate underlying mechanism of intensification and weakening of Asia-Pacific monsoon circulation intensity in the backdrop of heterogeneous global temperature change.	• Heteorologenity in the global tropospheric temperature change has been documented quantitatively in details. • Life cycle of Asia-pacific monsoon circulation is studied in details by preparing and analyzing climatological maps of annual variation of global atmospheric parameters e.g Temperature, mean sea level pressure, geopotential height, geopotential thickness, Precipitable water, u and v wind
Determination of commencement and cessation dates of monsoon circulation and start and finish of monsoonal rains.	• An objective criterion is developed to delineate the area under monsoonal rains across the globe. • The criteria is modified further in order to determine start and end of monsoon rains across Indian subcontinent.

Recommendations of Working Group/TAC/GB:

The work will be presented first time.

Analysis and Results:

(1) Dataset collected/used:

Data Source (1): NCEP Climate Forecast System Reanalysis (CFSR) 6 hourly products from 1979-2014 at 2.5X2.5 degree resolution

Parameters: Temperature, Geopotential height, U and V wind at 12 isobaric levels

Mean sea level pressure, and Precipitable water

Data Source (2): TRMM satellite-IMD guage merged (NMSG) rainfall products at 1 degree resolution

(2) Asymmetry in the global tropospheric temperature:

A three dimensional structure of the global tropospheric temperature with special emphasis on the Middle East, Tibet-Turkey sector is quantified in details. Recent changes in the tropospheric temperature over different parts of the globe are also studied in great details. During July-August, the tropospheric temperature over south Asia's cordillera (Tibetan-Himalaya-Karakoram-Hindukush Highlands or THIKHIHILs; 25°–40°N; 60°–100°E) is greater than 6°-8°C than that over the equator. During this time of the year, the troposphere over the THIKHIHILs is warmer compared to that over the northern hemisphere by 6.3°C, north tropic 3.4°C, north temperate 7.1°C, north pole 14.8°C, southern hemisphere 14.7°C, south tropic 5.9°C, south temperate 19.1°C and south pole 35.4°C). An intense north-south TT contrast operates in the background of this anomalous thermal structure in and around THIKHIHILs. The NH is warmer than SH 8.4°C, north tropic than south tropic 2.5°C, north extratropic than south extratropic 14.2°C, north temperate than south temperate 11.9°C and north polar than south polar 20.6°C. In this global thermal setting and large contiguous landmass in north and west and vast water bodies in east and south, the cordillera acts as an elevated (~4.5km) heat source and the area experiences a strongest troposphere upwelling. The entire area between equator and Middle East-Mongolia sector experiences higher TT and lower MSLP than the equator. An inward intense pressure gradient in the lower layers and outward pressure gradient in the upper troposphere develops in and around the THIKHIHILs facilitating unusual lower level convergence, upper level divergence. The combined effect of temperature contrast between THIKHIHILS in the northern hemisphere and other parts of the globe is the main cause of occurrence of this large-scale monsoon. The outflows from upper tropospheric anticyclone are scattered in all directions and subsidence occur over eight deep highs across the globe – six great oceanic subtropical highs

Though the JJAS troposphere temperature over the globe has increased by 0.59°C from 1949-1978 to 1979-2009, the rise is more over the southern hemisphere (SH) (0.87°C) than the northern hemisphere (NH) (0.32°C) resulting into reduction of the troposphere temperature gradient (TTG) from NH to SH by 0.55°C.

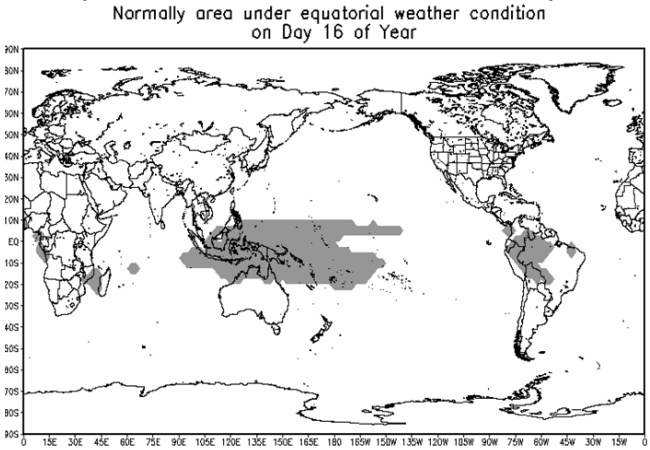
(3) Life cycle of Asia-Pacific Monsoon Circulation:

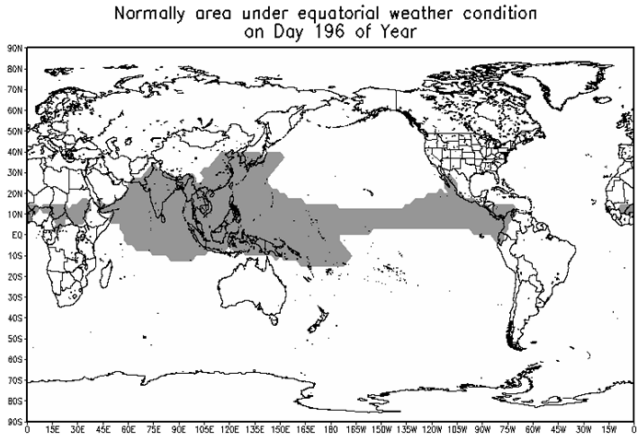
The equator is well known for hot-humid-cloudy-rainy weather. Short period spreading of equatorial weather conditions as regular annual event (seasonal) during which a region receives considerable portion of its annual rainfall is popularly known as monsoon. Following north-south oscillation of the Sun, five stages can be recognized in the spreading of equatorial thermal, circulation and moisture fields occurring in the order: troposphere (1000-200-hPa) warmer than that over the equator, lower tropospheric convergence and upper tropospheric divergence,

persistent large-scale moist airstream, development of synoptic scale weather systems and frequent convective clouds, rains and rainspells. The Asia-Pacific monsoon of the boreal summer is the largest and most intense. Eighteen types of convergences are formed across Asia-pacific region between large-scale dry airflows from north and northwest and moist airflows from east, southeast, south and southwest. The rising air from different convergences joins the outflow from the THIHKIHILs anticyclone in the upper troposphere. Regional, subregional and local factors (dynamic, thermodynamic and moisture) strongly affect these convergences giving rise of different regional/subregional monsoons. Their intensities also vary sometimes coherently while others antagonistically or independently. Nevertheless, they are interconnected as they are integral component of the same large-scale atmospheric circulation system (Asia-Pacific Monsoon).

(4) Delineation of Area under monsoon condition:

Departures of different atmospheric parameters from equatorial values at different isobaric levels are considered in order to determine area under normal monsoon condition. Normally, largest spreading of equatorial thermal condition occurs during beginning of July through middle of August. Normally, largest spreading of equatorial thermal condition occurs during beginning of July through middle of August. tropopause is located at 250-hPa over North Pole and beyond 100-hPa over South Pole. Spreading and intensification of equatorial low-pressure area follows that of the thermal spreading from April through May. During July–mid-August, the low pressure area becomes larger much beyond the boundary of thermal spreading due to its merger with subpolar low. The PW field follows the spreading of areas of low pressure and convergences (collision, horizontal shear and meander of large-scale equatorial-maritime moist airflows, orographic effect and Coriolis Effect) but within the confines of the thermal spreading. Following figure shows the spreading of monsoon area (based on temperature, mean sea level pressure and Precipitable water) at southern and northern hemispheric summer.





Adopters of the results of the study and their feedback:

- Funding Agency
- Operational Forecasters if interested

List of deliverables:

Project Report and journal Publications

Major items of equipment procured:

1. Workstation
2. Printer
3. UPS

Lab facilities during the study:

None

Data generated in the study:

Yearwise onset and withdrawal dates of Monsoon across Asia-Pacifc region as well subdivisions of India

Study Benefits/Impact:

The results from this study will be helpful in order to develop operational forecasting scheme for the prediction of yearwise onset and withdrawal of summer monsoon across the country. The study will also give some insight about the relationship between occurrences of extreme rain events and changes in general circulation features in order to cope up their consequences in advance.

Specific linkages with Institutions/beneficiaries:

None

Shortcomings/Difficulties:

Shortage of observational data in order validate the results

Future Plan:

To develop round-the-year real-time global monitoring system for prediction of weathers across Indian subcontinent.

WORK PROGRAMME FOR THE YEAR 2015-2016

SN	Title	Study Team	Duration	Funding (Rs. in Lakhs)
Completed Sponsored/ Internal Studies				
1.	Glaciological studies of Phuche Glacier, Ladakh Range, India	Renoj J. Thayyen M K Goel S P Rai	5 Years 1/10-06/15	DST (56)
2.	Assessment of Environmental flows for Himalayan River	Sharad K. Jain Pradeep Kumar P. K. Agarwal P. K. Mishra	1 Year 07/14-11/15	MOES (8.61)
3.	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)
Ongoing Internal Studies				
1.	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	3 Years (04/13-03/16)	NIH (16)
2.	Assessing climate change impact across KBK region of Odisha	P. K. Mishra Sharad K. Jain Sanjay K. Jain	3 Years (04/13-03/16)	NIH (28)
3.	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 (12)
4.	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 (48)
5.	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain Tanvear Ahmad M. K. Goel Sanjay K. Jain M. K. Nema	2 -3/4 Years (06/14-3/17)	NIH (23)
6.	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)
7.	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. K. Nema	2.25 years Dec. 2014 – Mar 2017	NIH
8.	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years Dec-2014 to Nov.2017	NIH (38)
9.	Hydrological process and characterization of Lesser Himalayan Catchments	M. K. Nema Sharad K. Jain Sanjay K. Jain	5 Years 12/14-12/19	NIH+

		Renoj J.Thayyen P. K. Mishra P. K. Agarwal		
10.	Development of Ganga Information Portal	Deepa Chalisgaonkar Sharad K. Jain D. S. Rathore Sanjay K. Jain Sudhir Kumar P. K. Mishra P. K. Agarwal M. K. Nema	3 years (04/15-03/18)	MoWR (65.55)
11.	Study of hydrological changes in selected watersheds in view of climate change in India.	L. N. Thakural D. S. Rathore Surjeet Singh Tanvear Ahmad Sanjay K. Jain Sharad K. Jain	3 years (04/15-03/18)	MoWR (44.30)
Proposed New Internal Studies for the year 2015-2016				
1.	Studies on Temporal Variation of Sediment Yield in Hilly Watershed of Upper Ganga Basin, Uttarakhand	P.K. Singh Sharad K. Jain Sanjay K. Jain M. K. Nema	2 Years 01/16-12/17	NIH (8.20)

COMPLETED STUDIES

SPONSORED RESEARCH PROJECT: NIH/WRS/2015/01

1. **Thrust Area:** Himalayan Cryosphere and Climate Change
2. **Project team:** Dr. R.J. Thayyen, Dr. S.P. Rai & Dr. M.K. Goel
3. **Title of the project:** Glaciological studies of Phuche Glacier, Ladakh Range.
4. **Objectives**
    1. Winter & Summer Mass Balance studies by glaciological method
    2. Runoff measurements
    3. Collection and standardization of meteorological parameters by AWS
    4. Mass Balance & Runoff modeling
    5. 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.
5. **Present state of the art**

   Most of the glacier mass balance research in the Himalaya is concentrated in the monsoon regimes of Uttarakhand and Himachal Pradesh. 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.
6. **Methodology**
    a) Procurement and installation of equipments
    b) Yearly winter and summer mass balance measurement
    c) Glacier runoff measurements
    d) Year round monitoring of meteorological parameters and standardization
    e) Mass balance & runoff modeling
    f) Stable isotope characterization of winter snow pack, summer rain/snow and stream flow
    g) Hydrograph separation by isotope method.
7. **Research outcome:** Glacier mass balance data inclusive of winter and summer mass balance of two glaciers in the Ladakh Himalaya. Assessment of prevailing climate and its orographic controls. Isotope based assessment of stream flow components and its seasonal variations. All these insights will be useful for managing the scarce water reserve of the Ladakh region.
8. **Cost estimate :**
    a. Total cost of the project: Rs. 56 lakhs
    b. Source of funding: DST

9. Analysis and Result: Summary

- The glacier catchment monitoring strategy has brought out the huge precipitation gradient along the steep mountain slopes in the catchment in winter which forces a winter accumulation of 590 mm w.e. on the glacier in comparison to less than 50 mm w.e.of winter precipitation at the valley bottom. This steep precipitation

gradient in winter is one of the key forcing factors sustaining the glaciers in the region. An altitude-precipitation relationship has been developed for the region.

- Extra ordinarily steep temperature gradient in summer with monthly mean values ranging around 10K/km persisting through March/April to September every year is brought to light for the first time. This steep temperature gradient is due to the summer aridity experienced by the region which forces cooler environment along the ridges which helps to sustain these glaciers. It is opined that the summer aridity is another important factor sustaining the Ladakh glaciers. Indices for deriving the slope environmental lapse rate (SELR) of two distinct lapse rate altitude have been developed.
- The snow accumulation pattern over the glaciers or the precipitation regime is found to have huge influence in the mass balance response. Years which experienced extended snowfall well into the month of June tend to have lesser glacial melt and there by more positive mass balance. Two slightly positive mass balance years are forced by similar precipitation regime. Glacier mass balance variability is found to be essentially driven by the temperature and precipitation variability during May and June months. This finding is contrary to general belief that the glacier mass balance is controlled by July-August melting as these months experience highest temperatures over the glacier regime.
- During the five years of glacier mass balance studies, two years experienced slight positive mass balance and three years experienced significant negative mass balance. It is seen that the negative mass balance years are capable of obliterating number of years of mass balance surplus. Hence the cumulative mass loss of Phuche glacier during the five year study period was -925 mm w.e. with mean annual mass balance of -185 mm w.e. Glacier mass balance response is found to be closely associated with the glacier ice exposure dates.
- The tandem mass balance studies conducted over the Khardung glacier shows significant higher glacier melt of Khardung glacier. Khardung glacier experienced negative mass balance though out the observation period and experienced a cumulative mass loss of 2688 mm w.e. during four years of observation with an average annual mass loss of -672 mm w.e.
- Estimated average degree days factors of snow and ice during the study period is is 0.00415 m w.e./ ^{o}C/day for DDFsnow and 0.00607 m w.e./ ^{o}C/day for DDFice.
- Water availability for the 15.7 km^2 experimental catchment in summer averages at 9.87 x10^6 m^3 equivalent to 624 mm w.e. of specific runoff. This is a significant discharge considering very low precipitation, <100 mm in the valley. Glacier contribution to the catchment runoff is estimated as 4.2 to 7.3%.
- Three runoff scenarios linked with prevailing weather conditions are observed during the study period. During the years of extended May-June snowfall, around 80% of the runoff is generated in July and August months which is more or less equally distributed between these months as experienced in 2010. During the years of normal winter snowfall maximum runoff occurred in the month of July (35-40%) followed by around 25% in August as experienced in 2012 and 2014. The third category of runoff response is associated with early snow melt associated with higher temperatures in May and June. These years experienced more or less uniform distribution of discharge throughout the melt period from June to September with each month experiencing runoff of around 20-28% of the summer totals. This insight will hugely help the water management practices in this region and forecasts of monthly runoff variability will be beneficial for the people and agricultural activity.

- Further, daily runoff variability studies have shown that the effective water use practices in these areas should incorporate mid-noon to mid-night water use/storage during July and August months and mid-night to morning water use/storage in May – June months to make use of the daily peak flows. Study suggests significant ground ice melt contribution to runoff during the dry years. Presence of discontinuous permafrost is suspected and deeper studies on these aspects are required to understand the hydrology of cold-arid cryospheric system.
- May –June precipitation, which is most crucial for hydrologic and glacier response is found to be sourced mainly from the local evaporative moisture having enriched isotopic values with weighted average of -7.2‰ ($\delta^{18}O$) and -41.8 ($\delta\ ^{2}H$).
- Isotopic signatures of western disturbances very much present in the winter snowfall which is also depleted, weighted average of -17.0‰ ($\delta^{18}O$) and -128.7 ($\delta^{2}H$).
- Time lapsed sampling of snowpack has demonstrated the mixing of isotopic signatures of different snow layers through the melt period and resultant isotopic characteristics by the end of the melt season did not have the source signatures.
- Separation of hydrograph components were carried out by the isotopic method. As glacier melt contribution is less than 10% separation is attempted between snow/glacier melt and rainfall contributions. 2010 experienced highest rainfall contribution amounting 29% and the rest 71% contributed essentially by snow melt. Subsequent observation years, rainfall contributed only 7-9% of the annual runoff of the catchment.

COMPLETED STUDIES

SPONSORED RESEARCH PROJECT: NIH/WRS/2015/02

1. **Thrust Area:**
2. **Project Team:**
   a. Project Investigator: Dr. Sharad K. Jain, Scientist 'G'/ Head, WRSD
   b. Project Co-Investigators: Dr. Pradeep Kumar, Scientist 'C', WHRC
      Shri P. K. Agarwal, Scientist 'B'
      Shri P. K. Mishra, Scientist 'B'
3. **Title of the Project:** Assessment of Environmental flow for Himalayan River
4. **Type of Study** - MOES Sponsored
5. **Amount** - 13.74 Lakhs
6. **Start Date** - Nov., 2014
7. **Scheduled date of completion** - Nov., 2015
8. **Status:**

   A draft final report has been submitted to the MoES, GoI. A presentation has also been made before the PAMC, MoES on 06th November, 2015. Final report is to be submitted after incorporating the suggestions from the PAMC members.

COMPLETED STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/03

1. Thrust Area under XII five year plan: Sustainable water systems management: Adaptation of hydro-system to climate change

2. Project team:

a. Project Investigator: Manish Kumar Nema, Sc 'C'
b. Project Co-Investigator(s): Dr. Sharad K. Jain, Sc 'G' & Head

3. Title of the Project: Variability of the Hydro-climatic variables in Punjab Plains of lower Sutlej

4. Objectives:

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

5. Present state-of-art

Capturing typical properties of time series, like trends, is highly relevant for the discussion of potential impacts of global warming or flood / drought occurrences. The majority of the Indian agriculture is dependent on the southwest monsoon, which brings about 80% of the total precipitation over the country which is critical for the availability of freshwater for drinking and irrigation. Changes in climatic variable over the Indian region, particularly the SW monsoon, would have a significant impact on agricultural production, water resources management and overall economy of the country. A pre-information regarding the changes can be ascertained by the analyzing the trend of these variables. Considering their importance, this study is proposed to understand the variability of the Hydro-climatic variables in Punjab plains of lower Satluj basin by performing standard trend analysis. The Punjab plain of lower Satluj basin up to Harike Barrage has been selected for the study in views of its important contribution in agricultural production for the country. The land surface of Punjab is one of the most fertile plains of India. The Satluj, Ravi and Beas are the major rivers flowing through the Punjab. The Satluj and its tributary Beas enters Punjab near Nangal and Talwara respectively. After moving about 450 km in the plains of Punjab, these two confluences at Harike before crossing over to Pakistan. On micro regional basis the Punjab plains may be divided into the Bari Doab (between the Beas and the Ravi) and the Bist Doab (between the Beas and the Satluj).

6. Methodology

Data Acquisition:

All possible hydro-climatic data and other related information shall be acquired, purchased, collected from various state and central agencies mainly includes Indian Meteorology Department (IMD); Central Water Commission (CWC); Bhakra Beas Management Board (BBMB); Ground Water Department, Govt. of Punjab; etc.

Processing of Acquired Hydrological data:

Integrated hydrological data base will be created in GIS environment after data pre-processing like identification and removal the data gaps, outliers etc.

Linear Regression and Mann–Kendall Test for Trend Analysis:

Prior to 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.

7. Research outcome from the project

Research Papers and Reports. Comprehensive database of the lower Sutlej in Punjab plains for the end users/beneficiaries from the relevant Sectors.

8. Cost estimate

a. Total cost of the project: Rs. 11.34 lakhs

b. Source of funding: NIH

c. Sub Headwise abstract of the cost

S. No.	Sub-head		Amount (in Rupees)
1.	Salary	160 man-days of Sci. – B @ 1600/day	509640
		67 man-days of Sci. – F @ 2740/day	183580
2.	Travelling Expenditure		30000
3.	Infrastructure / Equipment / Data		400000
4.	Experimental charges		0
5.	Misc. expenditure		10000
	Grand Total:		1133220

10. Work Schedule

a. Date of commencement of the project: 01/11/2013

b. Duration of the project: 2 years

c. Stages of work and milestone:

SN	Work Element	First Year				Second Year			
1.	Literature survey, Data collection/Monitoring/Field & Lab Investigation	■	■	■	■				
2.	Processing of Acquired Hydrological data			■	■	■			
3.	Linear Regression and Mann–Kendall Test for Trend Analysis and Magnitude of the Trends				■	■	■		
4.	Analysis & Interpretation of data using computer program/model output					■	■	■	■
5.	Preparation of Papers/ Report				■				■

11. Progress till date:

The time series of the monthly rainfall, maximum and minimum temperature as well as the pre-monsoon and post-monsoon ground water level for the study area have been tested for the presence of trends and their respective magnitudes. The results have also been presented in the previous working group meetings. Due to high regulation and missing intermittent discharge data of the lower Sutlej at Harike and Ropar, the MK and Sen's slope for understanding the trends were not applied and period of the study has been reduced to two year (completed now). The reference evapotranspiration (ET_0) data of the study area has been analyzed for identification of trends and their magnitude on annual as well as seasonal basis. The average annual ET_0 of the study area is about 1721mm with 26 mm standard deviation and coefficient of variation of 0.015. Annually, there is no trend (significant) in the ET_0, but seasonally the study area is significantly indicating trends. ET_0 in The Monsoon season is showing a falling trends at 99% confidence level, whereas, the winter and spring season are showing the rising trends at 95% and 90% confidence level respectively.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/01

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

2. Project team:

a. Project Investigator:	Dr. M. K. Goel, Sc. "G"
b. Project Co-Investigator(s):	Dr. Sharad K. Jain, Sc. "G"
	Smt. D. Chalisgaonkar, Sc. "F"
	Mr. P. K. Mishra, Sc. "B"

3. Title of the Project NIH_Basin – A WINDOWS based model for water resource assessment in a river basin

4. Objectives

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.

5. Present state-of-art

A detailed spatially distributed model has been developed to assess various components of the hydrological cycle in a river basin. In this model, focus is given to incorporate spatial variation of land-use, soil type, rainfall, evapo-transpiration, physiographic characteristics, cropping pattern, irrigation development, groundwater conditions, river network and hydraulic structures in a river basin. GIS is employed to link the spatial data with the simulation model and to project the model results in map form for easy visualization.

The model is in continuous phase of development. Some of the present limitations of the model which are planned to be addressed 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) continuous long-term simulation, and v) simplified representation of groundwater simulation. It is proposed to prepare input data files through user-interactive forms.

6. Methodology

For approximating the EAC relationships for a reservoir, the approach developed by J. Mohammadzadeh-Habili et al. (2009) has been adopted, avoiding the necessity of specifying EAC tables for various reservoirs in the river basin. Rule-curve based approach has been added in the FORTRAN code for simulating the reservoir operation as per specified operation policy. The option of hydropower simulation of a reservoir has also been added.

Model is planned to work in two modes: 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.

In WINDOWS interface of the model, various data input forms are being developed. Four important modules of the software include:

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

The "Database Preparation" module is planned to include forms for the entry of attribute and temporal data of hydrological variables and model parameters. In the "GIS Analysis" module, it is planned to link the free domain GIS (ILWIS system) for creating and processing geo-spatial data. This module will also contain provisions for converting raster data to ASCII format. In the "Model Execution" module, various sub-models which are run for aggregating spatial information will be provided. In addition, the main Basin model will also be provided in this module. In the "Analysis of Results" module, provision will be made to view spatial and hydrological results of the model.

7. Research outcome from the project

Research outcome from the project is a WINDOWS based spatially distributed river basin planning and management model for integrated water resources assessment and management at basin scale. The study can help water resources departments and river basin authorities in the analysis at river basin scale. It can also help in assessing the impact of various natural and anthropogenic activities on various components of the hydrological cycle at basin scale.

8. Cost estimate:

a. Total cost of the project: Rs. 16.00 lakhs
b. Source of funding: NIH
c. Subhead-wise abstract of the cost

S. No.	Sub-head	Amount (in Rs.)
1.	Salary of Scientists	Rs.15,00,000/-
2.	Travelling expenditure	-
3.	Infrastructure/Equipment	-
4.	Experimental charges	-
5.	Misc. expenditure	Rs.1,00,000/-
	Grand Total	Rs.16,00,000/-

9. Work Schedule:

a. Date of commencement of the project: April 01, 2013
b. Duration of the project: 3 years
c. Stages of work and milestone:

S. No.	Work Element	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Year 2015 - 16					
1.	Development of data forms & WINDOWS interface				
2.	Model testing and refinement				
3.	Report writing and User Manual preparation				

10. Present Progress:

A number of modifications have been made in the model methodology and the source code for making it more practicable and realistic. Some of these modifications include:

h) GW potential factors specified for two conditions – Temporal (based on increase in GW development) and Position (based on current average GW table in sub-basin.

i) Population of cities with known population within a district are added and compared with the population in the district. Unknown urban population in each district is uniformly distributed across various cities (with unknown population) in that district.

j) If a city takes water from a river segment, a diversion structure is assumed at the end of segment and water is diverted from the structure. So river network file needs to be created after considering city diversions.

k) Overland flow module using CN. Variable name for initial abstraction at 0.3 or 0.1 of rainfall in SCS method added which needs to be specified for various soil and AMC conditions.

l) Modification made in the input for specifying outlet from hydropower to join a stream segment or to go outside of the basin.

m) Value of ISC (irrigation source) specified in-between 1-999 for hydraulic structure (depending on number of hydraulic structure) irrigated areas, 0 for Rain-fed area, and 1000 for GW irrigated area.

n) For the conditions when there is no crop on a grid and next season crop is yet to be planted, consideration of a crop = 100 (with properties specified in crop file) is included. It is also assumed that irrigation application at a crop grid occurs on the first day of a week.

These modifications required changes in the input data. Therefore, it has decided to first complete the model modifications in the FORTRAN code and then develop the WINDOWS based forms for database preparation. The program development is nearing completion.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/02

1. Thrust Area under XII five year plan: Impact of climate change on water resources

2. Project team:

a. Project Investigator: Shri P. K. Mishra, Sc 'B'

b. Project Co-Investigator(s): Dr. Sharad K. Jain, Sc 'G' & Head
Dr. Sanjay K. Jain, Sc 'G'

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

4. 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

5. Present state-of-art

The proposed study envisages assessing the climate change effects in one of the poorest region in the country (KBK region, Odisha) regularly facing drought, water scarcity, and flood as well. The region is neglected with poor connectivity, resulting in increased Naxalite activities. With large-scale Govt. funding and concerted efforts, KBK region can be developed. Further, climate change and its impact on the water resources is also inevitable. The situation may aggravate in future. Therefore, a timely holistic study considering all the three undivided districts is essential to study the water resources problem in the region considering climate change.

6. Methodology

The study requires creation of a large database collected from primary and secondary sources and generated through Remote Sensing and GIS. The study commences with findings standard statistical characteristics for rainfall and temperature such as mean (μ), standard deviation (σ), skewness (Sk), kurtosis (Kk), and coefficient of variation (Cv) for monthly, seasonal and annual temporal scale. The seasonal assessment will include Pre-monsoon (April-May), Monsoon (June-September), Post-Monsoon (October-November) and Winter (December-March) period.

The long-term historic data is analyzed for detecting trend utilizing parametric (5-year moving average) and non-parametric tests (Mann-Kendall test; Sen's slope estimator). Unlike parametric test, the non-parametric tests are robust in nature and do not affected by outliers but certainly by randomness. Hence, the series of data were tried for detecting outliers and randomness before performing any test for trend detection. Standard Normal Homogeneity Test (SNHT) and Pettitt's Test are utilized to find the most probable year where the rainfall and temperature trend has been shifted considerably.

The downloaded large-scale daily predictors of Hadley Center's GCM (HadCM3) for HadCM3 A2 and B2 future scenarios for 139 years (1961–2099) on 3.750 latitude x 3.750 longitude grid-scale (http://www.cics.uvic.ca/scenarios/sdsm/select.cgi) is downscaled using

Statistical Downscaling Model (SDSM). The Statistical Downscaling Model (SDSM) is a multiple regression-based tool, introduced by Wilby et al. (2002), for generating future scenarios to assess the impact of climate change. HadCM3 is a coupled atmosphere-ocean GCM developed at the Hadley Centre of the United Kingdom's National Meteorological Service. HadCM3 has been chosen because of its' wider acceptance in many climate change impact studies. Further, it provides daily predictor variables, which can be exclusively used for the SDSM model. Water resources availability and utilization will be made using primary and secondary data collected through field visit and from different multiple sources. It is planned to utilize SWAT model to assess the water resources particularly the recharge component in the basin.

7. Research outcome from the project

a. Long-term trend of climatic variables viz. rainfall, temperature and potential evapotranspiration for the region
b. Future climatic scenario for the region
c. Water availability at present and in the future scenario vis-à-vis its present utilization

8. Cost estimate

a. Total cost of the project : Rs. 28.00 lakhs
b. Source of funding : NIH
c. Sub Headwise abstract of the cost

Sl No.	Sub-head	Amount (Rs.)
1.	Salary	25,80,000.00
2.	Travelling expenditure	1,00,000.00
3.	Infrastructure/ Equipment	0.00
4.	Experimental charges	0.00
5.	Misc. expenditure	1,20,000.00
	Grand Total:	28,00,000.00

9. Quarterly Break up of cost estimate for each year

Year: 2015-16

Sl. No.	Sub-head	Amount (in Rupees)			
		Q1	Q2	Q3	Q4
1.	Salary	1,92,500/-	1,92,500/-	1,92,500/-	1,92,500/-
2.	Travelling expenditure			50,000/-	
3.	Infrastructure/Equipment				
4.	Experimental charges				
5.	Misc. expenditure	10,000/-	10,000/-	10,000/-	10,000/-
	Sub Total	2,02,500/-	2,02,500/-	2,52,500/-	2,02,500/-
	Grand Total	Rs.8,60,000/-			

10. Work Schedule

a. Date of commencement of the project: April 01, 2013
b. Duration of the project: 3 years

c. Stages of work and milestone:

Sl. No.	Work Element	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Year 2013 – 14					
1.	Data procurement & Review of literature				
2.	Trend analysis				
3.	1st Interim report				
Year 2014 - 15					
4.	Downscaling				
5.	Inputs for SWAT model set-up				
6.	2nd Interim report				
Year 2015 - 16					
7.	Water resources assessment				
8.	Final report				

11. Progress till date:

Trends in long-term climatic data, i.e., rainfall (110 years), temperature (102 years), 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).

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, and presented in the 41st Working Group. After the last Working Group meeting, future temperature scenario in the KBK region has been downscaled from HadCM3 A2 and HadCM3 B2 GCM data utilizing SDSM model. The KBK region is falling mainly in two sub-basins viz. Tel and Sabari sub-basins. Indravati project, Patora dam are few projects meeting the irrigation and drinking water demand in the region. Apart from this, few multipurpose projects (major and minor) are in pipe-line such as Ong irrigation project, Lower Suktel project, Tel project, etc. under AIBP and RIDF programmes in the KBK region. The water availability and utilization for Tel basin (sub-basin to Mahanadi basin) has been completed. Daily discharge data for the Tel river for the duration 1972-2012 has been analyzed to compute annual dependable flow. The average annual yield for the basin is found to be about 9934 Mm^3 at 75% dependability. There are no major irrigation projects in the Tel basin. However, the combined annual utilization for drinking water, irrigation, and industry is about 4210 Mm^3. It is also planned to assess the recharge component into the ground utilizing SWAT model.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/03

1. Thrust Area under XII five year plan: Impact of climate change on water resources

2. Project team:

a. Project Investigator: Dr. Sanjay K. Jain, Sc "G"
b. Project Co-Investigator(s): Dr. Sharad K. Jain, Sc 'G'
Dr. Renoj Thayyen, Sc "D"

3. Title of the Project: Glacier change and glacier runoff variation in the upper Satluj river basin

4. Objectives:

- Collection and processing of historical data
- Apply future climate projections to see the changes in meteorological variables.
- Assessment of changes in glacier cover area using satellite data
- Modelling of glacier melt runoff and glacier mass balance
- Changes in glacier mass balance will be used to investigate glacier melt contributions.
- To obtain broader understanding of glacier change (spatial and temporal), reasons and their impact on glacier melt runoff.

5. Present state-of-art

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.

6. Methodology

- Creation of database of the study area(s)
- Glacier inventory and glacier change occurring in the study area.
- Trend analysis of past and future meteorological data
- Glacier mass balance study and 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

7. Research outcome from the project

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

8. Cost estimate

a. Total cost of the project: Rs. 12.00 lakhs
b. Source of funding: NIH
c. Sub Headwise abstract of the cost

Sl No.	Sub-head	Amount (in Rupees)
1.	Salary	10,00,000/-
2.	Travelling Expenditure	100,000/-
3.	Infrastructure/Equipment	Nil
4.	Experimental charges	Nil
5.	Misc. expenditure	100,000/-
	Grand total	1200000/-

9. Work Schedule

a. Date of commencement of the project: October 2013
b. Duration of the project: 3 years
c. Stages of work and milestone:

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

10. Progress:

Three sub basins of Satluj basin have been taken: Baspa, Tirunglhad and Spiti (shown in Figures 1 & 2). Glacier change has been computed using 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. Trend analysis of discharge data of three sites (Sangla, Thangi and Khab), temperature data (Raksham, Kaza, Kalpa) as well as snow water equivalent (SWE) have been carried out. The changes in glacier have been correlated with temperature. In the last working group it was suggested to see the changes in glacier cover with aspect. Aspect map have been prepared and the glaciers cover area vis a vis aspect have been prepared. The progress of the study will be presented in the meeting.

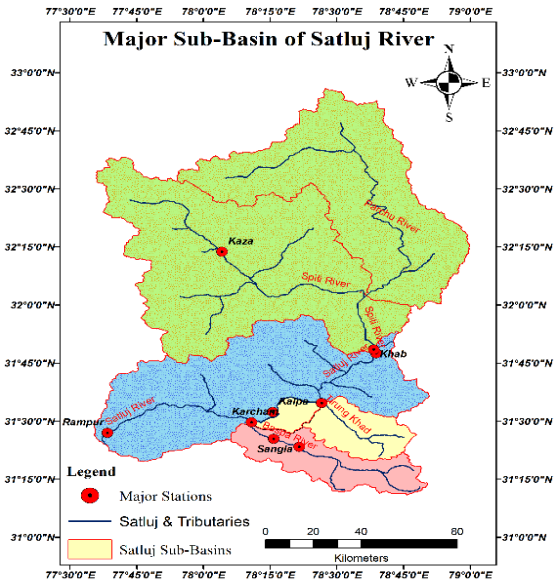


Fig. 1 Study area

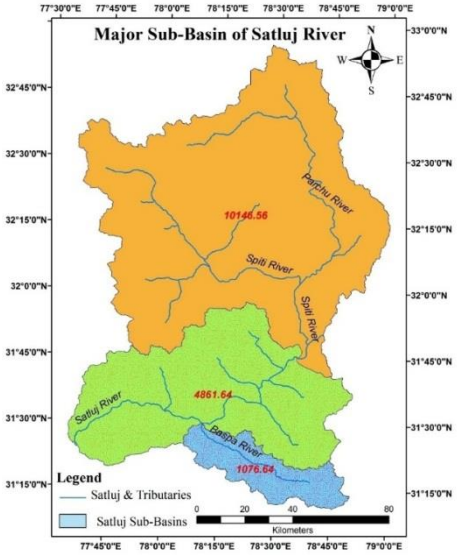


Fig. 2 Major sub-basins of Satluj River

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/04

1. **Thrust Area** **:** Himalayan Cryosphere and Climate Change
2. **Project team** **:** Dr. R.J. Thayyen, Dr.S.P. Rai, Dr**.** Sanjay Jain, Dr. Sudhir Kumar
3. **Title of the project :** Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh.
4. **Objective**
   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.
5. **Present state of the art:**
   Himalayan and trans- Himalayan regions of the country have many hydrological regimes. Role of the Himalayan cryospheric systems to the downstream river flow varies across these hydrological regimes. However, lack of data and research in these areas limit our understanding of these systems and thereby our ability to manage these systems under the changing climate. Cold-arid cryospheric system of the Ladakh is unique hydrological regime of the Himalayan system. The first phase of the project entitled "Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range" 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 (Phase-II) has aimed to expand the research preview to the foothill zones of the mountain to achieve a more comprehensive understanding of the cold-arid system hydrological processes with a view to assist people in managing these scarce resources.
6. **Methodology**
   a) 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
   b) Monitoring discharge and Electrical conductivity at 4700 m a.s.l & 3500 m a.s.l.
   c) Measuring ground temperature for permafrost studies
   d) Geophysical investigation of potential permafrost zones
   e) Isotope studies of stream discharge at 4700m a.s.l. and 3500 m a.s.l.
   f) Runoff modeling by SNOWMOD by incorporating the new SELR concept
7. **Research Outcome from the Project:** The project is aimed at quantifying various hydrological components in the catchment and its seasonal responses. Better understanding of the lean season winter outflow from the groundwater system is intended to bridge the critical knowledge gap of the mountain groundwater resources and its linkages with the surface water.

Understanding of the orographic processes and mountain climate at the nival/glacier systems to decipher the climate change impact on the cold-arid cryospheric system better.

8. Cost estimate:

a. Total cost of the project: 48 lakhs

b. Source of funding: NIH

c. Sub Headwise abstract of the cost

S. No.	Sub-head		Amount (in Rupees)
1.	Salary	Sr. Project Officer	800000
2.	Travelling Expenditure		500000
3.	Infrastructure / Equipment / Data		2500000
4.	Experimental charges		500000
5.	Misc. expenditure		500000
	Grand Total:		48,00,000

9. Work Schedule

S. No.	Work Element	First Year				Second Year				Third Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.	Monitoring weather												
2.	Monitoring Q												
3.	Permafrost temp.												
4.	Geophysics-permafrost												
5.	Isotope studies												

10. Analysis and result

This is a new study initiated in July 2014 in continuation of the studies of past 05 years in the Ladakh region (Fig.1). In view of the expanded research preview, a new discharge and meteorological station was established at 3700 m a.s.l. at Gonpa area. The discharge station was equipped with radar water level recorder to collect data though out the winter months. First week of August has seen heavy flooding in the area and the discharge station and water level recorder was badly damaged. Meteorological data is generated from 3700, 4700 and 5600 m a..s.l. and analysed. Discharge data from 4700m a.s.l is also generated during the reporting period and analysed. 2015 summer months experienced prolonged snow precipitation and snow cover duration in the catchment. Winter and summer mass balance measurement of Phuche and Khardung glacier is also carried out during the reporting period.

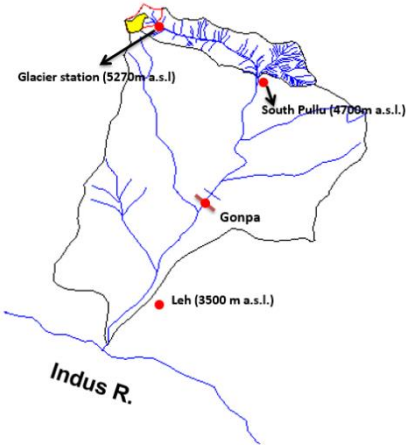


Fig.1. Study area showing South Pullu and Gonpa discharge stations and weather stations

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/05

1. Thrust Area under XII five year plan: Integrated water resources management/ watershed hydrology

2. Project team:

a. Project Investigator: Shri P. K. Agarwal, Sc B

b. Project Co-Investigator(s): Dr. Sanjay K. Jain, Sc G
Shri Tanvear Ahmad, Sc B
Dr. M. K. Goel, Sc G
Dr. Sharad K. Jain, Sc G

3. Title of the Project: Hydrological modeling of a part of Satluj basin using SWAT Model

4. Objectives:

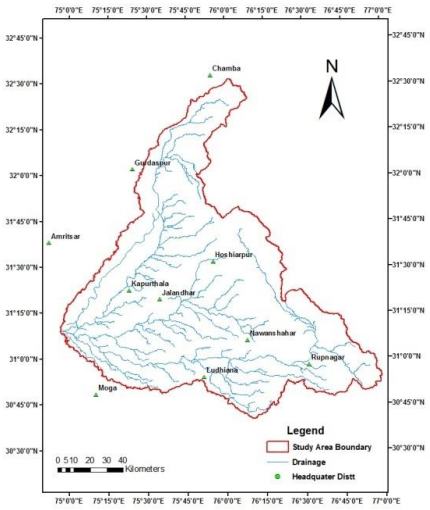
i. To develop the data base of a part of Satluj river basin (between Ropar D/s of Bhakra dam to Harike) and

ii. To carry out hydrological modeling of the basin using ArcSWAT model to find out water balance components, e.g. actual evapo-transpiration etc.

5. Present state-of-art

In the present study SWAT model is proposed for modelling. The Soil and Water Assessment Tool (SWAT) model is a river basin or watershed scale model developed by the USDA Agricultural Research Service. SWAT is a spatially distributed, continuous time model that operates on a daily time step. The model allows a basin to be subdivided into sub-basins or watersheds which is particularly beneficial when different areas of the macro-watershed are dominated by land uses or soils different enough in properties to have different impacts on the hydrological response. Within SWAT the input information for each watershed is grouped and is called hydrologic response units or HRUs. Model outputs include 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.

Study Area selected Satluj river basin (between Ropar D/s of Bhakra dam to Harike) as given figure:



6. Methodology

In the present study, the following methodology will be adopted:

- Data base preparation in ArcGIS (DEM, Land use, soil map)
- Collection of meteorological data (rainfall, temperature, wind, solar radiation, humidity)
- Setup, calibration and validation of SWAT model
- To understand the effect of land use & other changes on stream flows.

7. Research Outcome from the Project

Water balance components (runoff, evaporation, base flow, etc.) for the basin.

8. Cost Estimate:

a. Total cost of the Project: Rs. 23.00 lakhs
b. Sources of Funding: NIH
c. Sub head wise Abstract of Cost

S N	Sub Head	Amount (in Rupees)
1.	Salary	Rs. 15,00,000.00
2.	Travelling Expenditure	Rs. 3,00,000.00
3.	Infrastructure/Equipment/Data	Rs. 3,00,000.00
4.	Experimental Charges	-
5.	Misc. Expenditure	Rs. 2,00,000.00
	Total	Rs. 23,00,000.00

9. Quarterly Break up of cost estimate for each year

Year: 2015-16

Sl.No.	Sub-head	Amount (in Rupees)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Salary	150000.00	150000.00	150000.00	150000.00
2.	Travelling expenditure	40000.00	40000.00	40000.00	40000.00
3.	Infrastructure/Equipment	40000.00	40000.00	40000.00	40000.00
4.	Experimental charges	NIL	NIL	NIL	NIL
5.	Misc. expenditure	20000.00	20000.00	20000.00	20000.00
	Sub- Total:	250000.00	250000.00	250000.00	250000.00
	Grand Total	Rs. 10,00,000.00			

10. Work Schedule

a. Date of commencement of work June 2014
b. Duration of Work 2-3/4 Years
c. Stage of work and Milestone

SN	Work Element	First Year (2014-15)			Second Year (2015-16)				Third Year (2016-17)			
		Jun-Sep	Oct-Dec	Jan-mar	April-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jen	Jul-Sep	Oct-Dec	Jan-Mar
1	Literature Review & Data Collection											

2	Development of data base for a river basin for SWAT model										
3	Application of SWAT model										
4	Analysis of Results										
5	Preparation of Report										

11. Progress made between March 2015-Nov. 2015

Preparation and Processing of Soil and land use data

- Soil Maps Collected from NBSS Nagpur, and converted into digital form.
- Landsat L8 (2014) satellite imagery has been downloaded from Earth explorer and prepared Land use/land cover data for SWAT
- Sub-basin boundary has been delineated -- 34 sub-basins have been delineated along with two inlets at Beas and Satluj Rivers and Outlet at Harike barrage
- HRUs have been made
- Spatial soil and landuse data has been processed in SWAT Model

Preparation of Meteorological data

- Grided Rainfall, Minimum/Maximum temperature data of IMD has been downloaded from 1994-2006.
- Wind speed, solar radiation and Relative humidity has been downloaded from http://globalweather.tamu.edu
- Converted the meteorological data into .dbf files.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/06

1. Thrust Area under XII five year Plan: Integrated Water Resources Development and Management

2. Project team:

a. **Project Investigator**: D.S. Rathore, Sc F

b. **Project Co-Investigator(s)**: M.K. Goel, Sc G
R.P. Pandey, Sc F
Sanjay Kumar, Sc D
Surjeet Singh, Sc D

3. Title of the Project: Decision support system for water resources planning in Upper Bhima basin, Maharashtra

4. 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

5. Present state-of-art

A Decision Support System (Planning) has been developed under Hydrology Project - II for State and Central implementing agencies. The project has two components, namely DSS platform and modelling systems. For modelling system, MIKE HYDRO Basin model was chosen. This is a water allocation model which also has conceptual lumped rainfall- runoff model NAM in built for generation of long term runoff time series. The platform has GIS, spreadsheet, scenario, script, time series and dashboard (for web applications) managers. On the platform, data and model scenarios may be handled. The scenarios are run with available MIKE HYDRO Basin engine.

6. Methodology

MIKE HYDRO Basin is being used and database for the Upper Bhima basin up to Ujjani dam developed in HP-II project will be transferred to the new system. Rainfall- runoff modelling will be done using NAM for finding different hydrological components at sub-basins scale. Rule curves would be developed for various project complexes and multi reservoir operation would be carried out to optimize the water use in the basin. Meteorological and hydrological drought indices would be computed using rainfall and hydrological data. Conjunctive use scenario in canal command areas will be run. River water quality modelling will be carried out. Web-interfaces through Dashboards would be developed for dissemination of input and results of simulation in DSS (Planning). Downscaling will be done for climatic scenario. Downscaled climate data will be utilized and model runs would be taken to find their impact on the water availability and allocation in the basin.

7. Research outcome from the project

a. Water availability in various sub-basins in present and changed future climate.
b. Reservoir operation rules for existing and future climatic scenarios: Model was set up for reservoir operation and optimization in Khadakwasla complex.
c. Meteorological and hydrological drought indices: Data preparation was done for computing meteorological drought indices.
d. Conjunctive use in canal command areas.
e. River water quality modeling in river reaches and impact of climate change: Water quality model was set up.
f. Interfaces for decision support.

8. Location map/ study area

Upper Bhima basin up to Ujjani in Maharashtra state

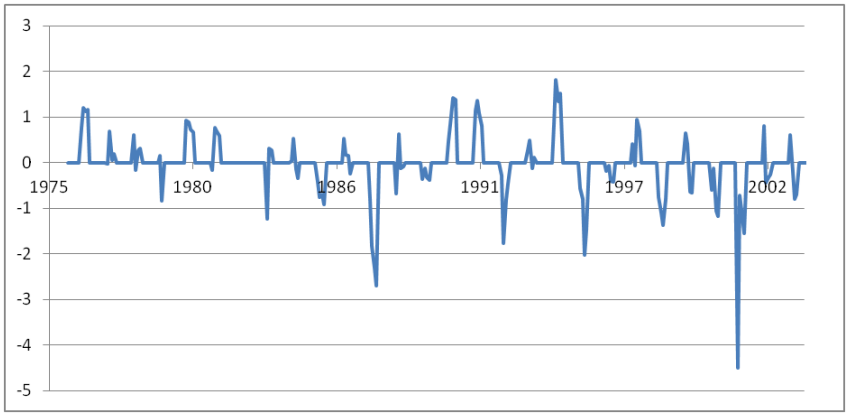
9. Approved action plan and time line

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							

10. Achievement:

Drought prediction

Streamflow drought index (SDI) was computed for inflow to reservoirs. For SDI reference period started in June and ended in each month (June-September). Fig. shows SDI for Tata Andhra project.



Water quality modeling in the basin

Pollutant load is calculated source wise using population (interpolated values for rural, urban: municipal corporation area, other areas), livestock population

and per unit load and total pollutant for agriculture source. Effluent pollutants were considered as diffuse source. Population fraction contributing to untreated sewage was taken from estimated values of pumped and generated sewage. Measured (BOD) and assumed (N, P, E Coli) concentrations and discharges were used in computing effluent pollutant load. Assumed per unit BOD, N and P load were in decreasing order for cattle, pigs, urban, rural population and goat. Assumed per unit E coli load was in decreasing order for pigs, urban and rural population, cattle and goat. Multiplying factors (pollutant attenuation in flow path) were varied for calibrating the river water quality. Factor of 0.1 for rural, livestock and fertilizer, 0.15 for urban and 0.2 for municipal corporation and STP effluent provided good results for simulation for year 2006. Simulated and observed values of water quality variables for Daund (blue color) and Koregaon are shown in graph (BOD, NH3-N, NO3-N, P and E Coli). Koregaon has relatively pristine conditions and Daund is a station at lower part of basin showing cumulative effect of basin. Simulated and observed (averages) are also compared.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/07

1. Thrust Area under XII five year plan: Hydrology for sustainability of water resources

2. Project team:

a. Project Investigator:	Dr. Sanjay K. Jain, Sc G
b. Project Co-Investigator(s):	Dr. Sharad K. Jain, Sc G
	Er. T. Thomas, Sc D
	Er. P K Mishra, Sc B
	Er. Manish Nema, Sc C
	Er. P.K. Agarwal, Sc B

3. Title of the Project: Modelling of Narmada Basin Using GWAVA Model

4. Objectives:

A major goal of the proposed study is to do hydrologic modeling of the basin. 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.
- Modelling of rainfall runoff.
- Impact of changes on stream flow in the basin.

5. Present state-of-art

Accurate water resources assessment and re-assessment is need of the hour in view of the altered water demand and utilization scenario world-wide. This requires robust hydrological model to accurately assess the water availability at present and in the future. Narmada basin is one of the highly regulated basins in India. Several water resources projects are being implemented, under construction and proposed in the basin. Since last few decades, urbanization and population growth has also driven additional water requirement in the basin. This requires revisiting water resources assessment in the Narmada basin.

6. Methodology

Study area: Narmada basin up to Hoshangabad including Tawa basin (D/s of confluence with Tawa)

GWAVA is a hydrological model which incorporates additional water resource components such as reservoirs, abstractions, and water transfers that modify water quantity and flow regime. It was developed with funding from DFID (UK Department for International Development). The model typically operates on 0.5 or 0.1 degree latitude-longitude grid. The choice of grid size is a compromise between that needed to represent spatial variability and the availability of suitable data. The model outputs include simulated monthly flows and a cell-by-cell comparison of water availability. GWAVA can be used to examine scenarios of change, both for climate and water demands.

Inputs for first tier GWAVA application

- Spatially and temporally explicit inputs
    - Rainfall, temperature (at least daily resolution)

    - Potential evapotranspiration or wind speed + relative humidity + solar radiation (at least daily resolution)
    - If the modelled area does not include some upstream areas: River discharges into the modelled area
- Spatially explicit inputs
    - Elevation or flow direction grid
    - Coverage by different irrigated crop types
    - Map of rivers and other water bodies
    - Soil texture and land cover
    - Lake, reservoir and wetland parameters (areal cover, maximum water volume, vertical shape, type of reservoir)
    - Urban and rural water demand per capita, Industrial water demand
    - Rural population and total population, Cattle, sheep and goat population
- Temporally explicit inputs
    - Gauged river discharge
- Parameters (constants)
    - Per capita water demand for sheep, goats, and cattle
    - Irrigation efficiency
    - % Leakage from urban and rural water supply systems
    - % return flow
    - Crop characteristics and growth stage durations for individual irrigated crop types, and the start and end of their growing season

Once the database data base of the study area(s) is collected and/or procured, model set up will be done. Then model will be calibrated and validated before going for sensitivity analysis.

7. Research Outcome from the Project

- Stream flow from the study area
- Water balance components (runoff, evaporation, lateral flow etc) for the sub-basin.

8. Work Schedule

a. Date of commencement of work — November 2014
b. Duration of Work — 2-3/4 Years
c. Stage of work and Milestone

1st. Interim report	2nd. Interim report	Final report
April 2015	April 2016	March 2017

9. Progress

The study area for the application of GWAVA Model has been selected as Narmada basin up to Hoshangabad in Madhya Pradesh. The hydro-meteorological data have been procured from India Meteorological Department, Pune. Similarly the hydrological data have been obtained from Central Water Commission, Bhopal. A training course on the Application of GWAVA Model (Part I) has been organized in the first week of March, 2015. Also the Part II of the training on GWAVA Model Setup had been organized during June 2015 at Wallingford, UK. Efforts have been initiated to setup the model for the study area. The data layers pertaining to the land use/land

cover have been completed. Similarly, the data layer of soil classification and Digital Elevation Model (DEM) has also been completed in GIS format. The data required by the model in the gridded format have been extracted from these GIS layers. Most of the mandatory inputs required by the model are ready. Presently the season-wise cropped area data is being prepared in GIS and the necessary data for the model run shall be extracted thereafter. An attempt has been made to have a virgin run of the pre-calibrated model at the outlet of the study area i.e. Hoshangabad. The model has run without any errors in the virgin run without cropped data and reservoir inputs. Efforts are being made for single site calibration as well as multi-site calibration of the GWAVA model, after incorporating the cropped data, reservoirs, and water transfers.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/08

1. **Thrust Area under XII five Year Plan**: Himalayan Cryosphere and Climate Change
2. **Project Team:**
   Project Investigator: Dr. R.J Thayyen, Sci-D
   Project Co-Investigators: Dr. Sanjay Jain, Sci-G
3. **Title of the Project:** Runoff modelling of Shyok River, Karakorum Range
4. **Objectives:**
   1. To generate runoff data at Km 150 for BRO-HIMANK
   2. To develop a baseline runoff and meteorological data of Shyok basin
   3. Runoff modelling of Shyok River at KM 150 & Shyok village
5. **Present state-of-art**

   Within the upper Indus region, the Shyok basin has the largest number of glaciers enumerated at 2454 covering a 10810km^2. Comparing to this, the Indian Himalayan region contributing to Ganga-Brahmaputra river system only have 1578 glaciers covering just 3787km^2 of glacier cover (Data Source Raina& Srivastava,2008 sourced from GSI glacier inventory 2009). However, glaciers and cryospheric system in this region is not received the due attention till date. Discharge of Shyok river is not monitored and its hydrological characteristics and resource potential is not known. The border roads organisation, HIMANK project is in urgent need of discharge data of Shyok river for strategic purpose and the present project is planned to fulfill this requirement for BRO.

   It is well accepted that the Karakorum glaciers are gaining mass in the recent past. Long –term monitoring of River Shyok will provide valuable information on river flow response of a glacier fed river under positive mass balance regime. Being a trans-boundary river this information will be very useful different national agencies. The automatic weather station proposed in the study will be the first comprehensive weather station in the region and will provide crucial input to the armed forces and data required for snowmelt runoff model. The ongoing study in the Ladakh range south of the Karakoram in the cold-arid system has shown that the glaciers are losing it mass. The proposed study will provide an interesting comparison between two contrasting glacier systems in the Himalaya.

   Head water region of the Shyok river originating from the Remo glacier has couple of surging glaciers such as Chonh Kumdan, Kichik Kumdan and Aktash glacier. Under the mass gain these glaciers are potential to surge. The Kumdan floods during 1929 to 1932 due to bursting of a 16 km long lake formed by blocking of River Shyok by the surging Kumdan glacier was devastated the Shyok basin. Hence monitoring of Shyok river is necessary for civilian and defense perspective. Hence the proposed study is being taken up by the above objectives.
6. **Methodology**
   1. Monitoring of weather parameters and discharge by AWS at Km 150 (5600 m a.s.l.) for generating climate data for runoff modeling.
   2. Generation of snow cover depletion curves through melt season
   3. Runoff modeling by SNOWMOD and Win SRM at this two stations

7. Research Outcome from the project: Discharge & Meteorological data, Research papers and project reports and better understanding of the Cryospheric response of the Karakorum mountains.

8. Cost Estimate

Total cost of the project: Rs. 37.64 lakhs
b. Source of funding: NIH
c. Sub Headwise abstract of the cost

S. No.	Sub-head		Amount (in Lacs)
1.	Salary	Resource person @Rs.22,000/- pm	2.64
2.	Travelling & Fieldwork		3.0
3.	Permanent Equipments (AWS, AWLR etc)		28.0
4.	Contingency		3.0
5.	Misc. expenditure		1.0
	Grand Total:		37.64

9. Work Schedule

S. No.	Work Element	First Year				Second Year				Third Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.	Monitoring weather												
2.	Monitoring Q												
4.	Runoff modeling												

10. Analysis and result

Runoff data of Shyok River is generated at discharge station set up at km 150 at Durbuk-DBO road. Water level monitoring is carried out up to 5 minutes interval. The data is downloaded in the month of September 2015 from the remote site and analysis of the data has been carrying out. Intermittent flow velocity measurement is carried out at the discharge section. Cross section measurement of the discharge site is generated and discharge has been calculated. Snow cover depletion curves of the basin has been generated for snow melt runoff modeling.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH/WRS/2015/09

1. **Thrust Area under XII five Year Plan**: Sustainable water systems management: Adaptation of hydro-system to climate change
2. **Project Team:**
   a. Project Investigator: Manish Kumar Nema, Scientist 'C'
   b. Project Co-Investigators: Dr. S. K. Jain, Scientist 'G'/ Head, WRSD, Dr. Sanjay K Jain, Scientist 'G' Dr. Renoj J. Thayyen, Scientist 'D' and Mr P. K. Mishra, Scientist 'B'
3. **Title of the Project:** Hydrological Processes and Characterization of Lesser Himalayan Catchments
4. **Objectives:**
   a. To establish an instrumentation and experimental setup to measure various hydrological and meteorological variables in a watershed in the upper Ganga basin within the state of Uttarakhand for better understanding of their behavior and to study the dynamic linkages between the two.
   b. Analysis and comparison of estimated Evapotranspiration (ET) by different methods like RS/SEBAL, FAO56 method and actual field measurements
   c. To study the various water balance components in the watershed

5. **Present state-of-art**

Watershed is the basic unit at which the hydrologic processes are studied and is central to most of the concepts in hydrology. Many watershed studies are being conducted to understand the fundamental hydrologic and biogeochemical processes and their linkages with soils, vegetation, topography, climate, and management practices worldwide. These studies mainly involve modelling the natural processes but the vibrancy of experimental hydrology broadly across the areas of subsurface and surface hydrology and hydrometeorology still have a unique place of importance and no alternative.

In view of the state of affairs of existing models and studies addressing the problems of watershed hydrology, the major limitations might be characterized as mainly twofold. First, study basin designs have been limited by the black box concept and many misconceptions (e.g., the linearity, non-heterogeneity, additivity of hydrologic systems etc.). Second, operation has been substantially bounded by the hydraulic conception of these watersheds as isolated hydrological systems (Wei-Zu et al. 2013). Most of the watershed studies monitor only total runoff at the stream-outlet and the subsurface responses of the watershed are only estimated by hydrograph separation, etc. These characteristics undermine the formulation of a unified theory of watershed hydrology (Sivapalan et al. 2005) and the development of watershed models (Kirchner, 2006; Mcdonnell et al., 2007). There is a clear need to move beyond the status quo and expand from this narrow hydrological perspective to test hypotheses governing general behavior across topographies and scales, with the ultimate aim to advance the science of hydrology.

6. Methodology

(A) Study Area:

A Himalayan watershed of Hinval River up to Jijli in Upper Ganga basin (Uttarakhand) is proposed for the study. This study area is a paired watershed of two kinds. One of them is a forested catchment (undisturbed) and the other is an agricultural watershed with anthropogenic interventions including an urban habitat at Chamba (Uttarakhand). The geographical extent of the study area is from $30^0$17'N–$30^0$26'N latitude and $78^0$16'E–$78^0$25'E longitude. This area is a typical representative of a combination of lesser Himalayan hilly temperate climatic conditions with average annual rainfall range of 1200-1800 mm. The total area under study is about 120 km^2 (20 km^2 forested catchment and 100 km^2 the other one) with an elevation range of 999-2676 m. The location map of the watershed and their digital elevation model are given in the Figure 1. The stream in the forested sub-catchment is the source of drinking water for 87 nearby villages. A study of the topography and land use shows that the watershed is representative of the surrounding areas.

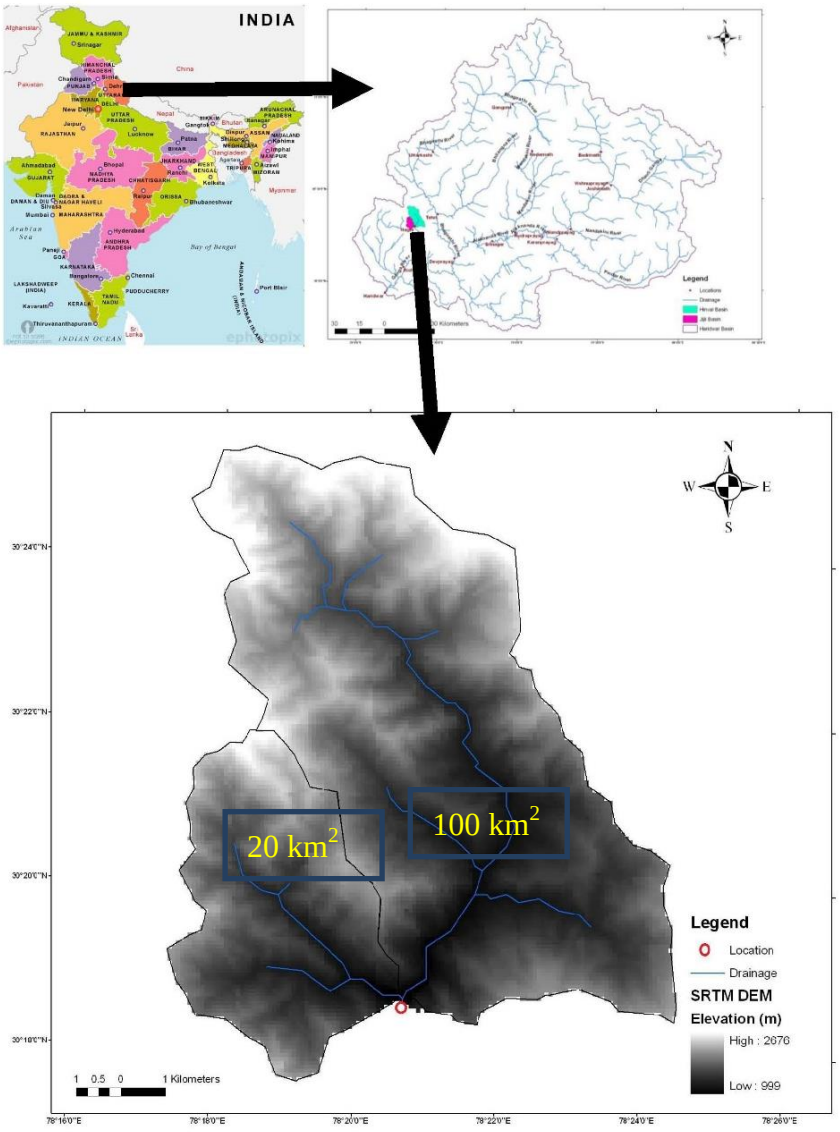


Fig. 1.0 Location of the Hinval watershed up to Jijli within India

(B) Experimental setup

Variables and parameters to be observed: organized in four categories, i.e., hydrological and ecological variables, atmospheric forcing variables, vegetation parameters, and soil parameters.

(C) Soil Heat Flux

Soil heat flux represents the amount of radiant energy absorbed or released at the soil surface during a given time period. Soil heat flux is a necessary input for many evaporation measurement and prediction techniques. One of the objectives of this study is to estimate soil heat flux using soil temperature collected at various soil depths. It is also intended to study the diurnal variation of soil heat flux in various seasons.

(D) Evapotranspiration (ET)

Accurate estimates of ET are needed for numerous agricultural and natural resource management tasks, hydrological modelling and to project changes in hydrological cycles due to potential climate change. In the present study, the estimates of ET from various sources will be compared with the actual field observations.

(E) Soil Moisture

Soil moisture in the uppermost 1–2 m of the earth's surface is recognized as a key variable in many environmental studies, including those related to meteorology, hydrology, agriculture and climate change. An understanding of the soil moisture variability is necessary to characterize the linkages between a region's hydrology, ecology and physiography (Jackson, 1993). The proposed objectives under this theme are to understand spatio-temporal variability of soil water potential and soil moisture content under different land covers in the temperate lesser Himalayan region and to evaluate differences, if any in spatial and temporal patterns of soil moisture content as influenced by nature of land cover. We propose to establish sampling points for measuring the soil moisture content under different land covers in selected watersheds, spread spatially to cover topographic highs and lows. Soil matric potential measurements are proposed using resistance-type probes. At each sampling point, probes will be installed at different depths. A roving instrument (handheld read-out unit) shall be used to record matric potential (kPa).

(F) Hydrologic Modelling

It is planned to apply distributed models such as the Soil and Water Assessment Tool (SWAT) and VIC Models

7. Research Outcome from the project:

Development of a world class field hydrological laboratory in the lesser Himalaya. Development of better understanding of monsoon forcing on regional hydrology under changing climate for the end users/beneficiaries from the relevant Sectors. Research Papers and Reports.

8. Cost estimates:

a. Total cost of the project: Rs. 90, 55, 000. 00
b. Source of funding : NIH
c. Sub-head wise abstract of the cost :

S. No.	Sub-head	**Amount in Rs. (Lac)**
1.	Salaries/ wages	33.60
2.	Travelling Expenditure	10.00
3.	Infrastructure / Equipment / Data	39.45
4.	Experimental charges	7.50
5.	Misc. expenditure	0.00
	Grand Total:	90.55

d. **Justification for sub-head wise abstract of the cost**: due to lots of instrumentation involve in the project the non-recurring cost is the major component followed by the salary of the project staff.

9. Quarterly Break up of cost estimate for Year: 2015-16

SN	Sub-head	Amount (in Rupees)			
		JFM (Q1)	AMJ (Q2)	JAS (Q3)	OND (Q4)
1.	Salary	168000.00	168000.00	168000.00	168000.00
2.	Travelling expenditure	50000.00	50000.00	50000.00	50000.00
3.	Infrastructure/Equipment	986250.00	986250.00	986250.00	986250.00
4.	Experimental charges	0.00	0.00	0.00	0.00
5.	Misc. expenditure	37500.00	37500.00	37500.00	37500.00
	Sub- Total:	1011800.00	1011800.00	1011800.00	1011800.00
	Grand Total:				4047200.00

10. Work Schedule:

a. Date of commencement of the project: 01.01.2015
b. Duration of the project: 5 years
c. Stages of work and milestones:

SNo.	Description of Activity	2015				2016				2017				2018				2019			
		J	**A**	**J**	**O**	**J**	**A**	**J**	**O**	**J**	**A**	**J**	**O**	**J**	**A**	**J**	**O**	**J**	**A**	**J**	**O**
1.	Development of Procedure for scientific work	■	■	■																	
2.	Recruitment and deployment of Project Personnel		■	■	■	■															
3.	Purchase of instruments and experimental setup			■	■	■	■														
4.	Data generation and acquisition					■	■	■	■	■	■	■	■	■	■	■					
5.	Data analysis and modelli														■	■	■				
6.	Final Reporting															■	■	■	■	■	■

10. Progress till date:

This is a field based project and major objective is to establish a classical hydro-meteorological field observatory in the Lesser Himalayan environment. Due to

monsoon season and flood level in the streams the construction activities could not start earlier. Now the establishment and construction of the gauging structure (a rectangular weir) has been started after monsoon and is in advance stage of construction. The tendering process for the automatic weather stations has been done. The land for its installation has been marked and the rent agreement with the land owner has been finalized. Due to some administrative issues the tender for the automatic water level recorder has been recalled and under process. The instrument setup and installation process may take another 2-3 months, subjected to administrative formalities. Once the installation done the man power deployment for the observation and security shall be the priorities. Since the project is about experimental hydrology, once we have some data in hand then some conclusive inferences can be drawn. In between, the project team also has visited the site on 04.03.2015, 27.03.2015 and 09.10.2015 for various objectives.

ONGOING STUDIES

INTERNAL RESEARCH PROJECT: NIH-E/WRS/2015/10

1. Thrust Area under XII five year Plan : Hydrological information

2. Project team:

a. Project Investigator: Deepa Chalisgaonkar, Sc F

b. Project Co-Investigator(s): Dr. Sharad K. Jain, Sc G
Sri D. S. Rathore, Sc F; Dr. Sanjay K. Jain, Sc G
Dr Sudhir Kumar. Sc G; Sri P.K. Mishra, Sc B
Sri P K Agarwal, Sc B; Sri Manish Nema, Sc C

3. Title of the Project : Development of Ganga Information Portal

4. Objectives

Ganga Information Portal is envisaged to provide a unique platform comprising multisource data and information on Ganga basin. The major objective for developing such a portal is:

- To develop a knowledge/ information e-portal (Ganga Information Portal) with updated information on Ganga basin
- To provide a world class platform as resource centre for data sharing, retrieving pertaining to Ganga basin
- To operate and maintain the e-portal on 24x7 basis

5. Present state-of-art

The Ganga is the most sacred as well as one of the most exploited rivers of India. With a vast geographical extent, varied climate, land use land cover, wildlife, demography and socio-economic situation in the entire Ganga Basin, tapping information for resource planning, R&D activities is a difficult task. There are lot of information on Ganga basin collected, collated, and compiled by different institutions/ organizations and agencies of both State and Central Governments. Many NGOs are also involved in different activities related to Ganga basin with possession of valuable information. There are also a number of books, journal papers, reports on Ganga basin. But this information is scattered, fragmented and unavailable on one platform to cater the need of multiple users.

Recently, the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD&GR) is emphasizing to restore the rivers into 'Nirmal' and 'Aviral' including Ganga. In addition to this, the government has launched the ambitious 'Namami Gange' an Integrated Ganga Conservation Mission with activities related with conservation and rejuvenation of the Ganga. Recognizing the multi-sectoral, multi-dimensional and multi-stakeholder nature of information in the Ganga basin, it is need of the hour to develop a web-based platform where different types of data/ information (facts; publications; data; maps; photographs; etc.) related to Ganga basin is available at one place. 'Ganga Information Portal' (GIP) is a step in this direction to develop a web-based information portal where variety of information on Ganga basin will be uploaded and maintained at National Institute of Hydrology, Roorkee.

6. Methodology

The GIP is being developed using World Wide Web (WWW) technology which is based on an open unstructured distributed hypermedia information system. It

consists of non-linear, flexibly linked HTML (Hyper Text Media Language) documents, in which different types of WWW objects are being embedded.

The system is being developed in HTML and java script language. The main and drop down menus will allow the user to interact with the system very easily. The information relating to the Ganga will be collected from many different sources, agencies and organizations and will be arranged between the time-spaces, and it will be possible to share, to search, to display, and to output (print) it.

7. Research outcome from the project

A portal as shown in Fig.1 will be developed which will support quick and timely access of the information related to Ganga, anytime and from anywhere in the world.

8. Cost estimate:

a. Total cost of the project : Rs.65.55 lakhs
b. Source of funding : NIH
c. Sub Headwise abstract of the cost

Sl. No.	**Item**	**Nos. required**	**Duration** (Man months)	**Unit amount** (Rs.)	**Amount** (Rs.)
A	**Manpower**				
i.	Scientist G and above	3	1 (Total)	175000.00	1750000.00
ii.	Scientist F	2	8	150000.00	2400000.00
ii.	Scientist B and C	3	1	80000.00	240000.00
iv.	JRF	2	30	28000.00	1680000.00
B	**Equipments (Hardware & Software)**				
	Workstations with UPS	2		50000.00	100000.00
	Scanner-A3	1		55000.00	55000.00
	Printer	1		30000.00	30000.00
C	**TA/DA**				
	Traveling by experts & JRFs	LS			300000.00
	Total (A+B+C)				**6555000.00**

d. Justification for Sub-head-wise abstract of the cost

a. Manpower: The manpower will be required for the information collection, development of the software, and management and operation of the portal. The roles of various persons involved has been given in para 8.
b. Equipments: Computer hardware and software will be required for the development, operation and maintenance of the portal.
c. TA/DA: At present more than 100 organizations are working on Ganga. They include various ministries, river basin organisations, central government organisations and undertakings, IITs, NITs, state government organisations, professional societies, NGOs etc. Some international organisations are also involved. Visits to these organisations may be necessary will be contacted for providing the information for inclusion in the portal.

d. Data: The data related to Ganga basin like hydrolological data, agriculture related data, water availability, demography, publications, climate data, ancient literature, cultural practices, religious scriptures, various maps etc. will be collected for putting on portal. If they are not freely available, they will be purchased.

9. Quarterly Break up of cost estimate for each year

2015-2016

Sl.No.	Sub-head	Amount (in Rupees)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1	Salary	365800.00	365800.00	365800.00	365800.00
2	Traveling expenditure	-	-	-	50000.00
3	Infrastructure/Equipment	-	-	-	185000.00
5	Misc. expenditure	-	-	-	50000.00
	Sub- Total:	365800.00	365800.00	365800.00	650800.00
	Grand Total				1748200.00

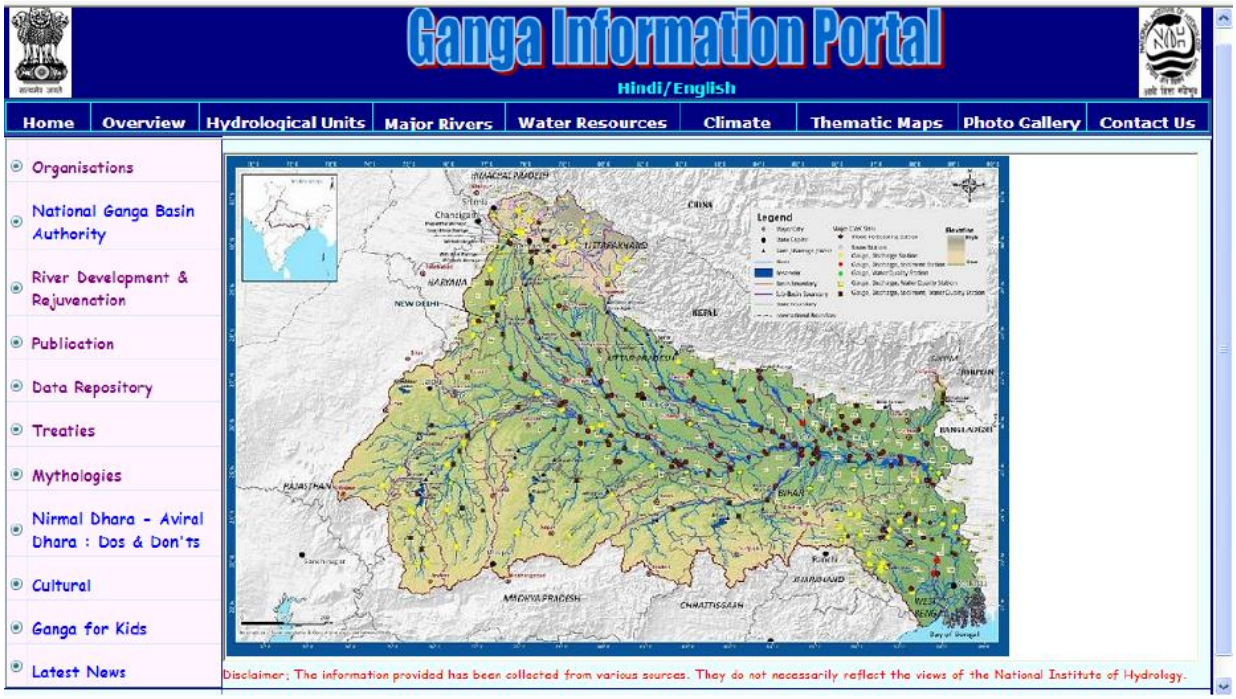
10. Work Schedule:

a. Date of commencement of the project : April 1, 2015
b. Duration of the project: 3 years, however, GIP is an integrated information portal which requires continuous efforts in upgradation and maintenance.
c. Stages of work and milestone:

Sl.No	Item/Activity	Timeframe
i.	Creation/ Establishment of Infrastructures	9 months
ii.	Collection of different types of data/ information from different stakeholders on Ganga basin	6 months & beyond
iii.	Portal development and management	6 months & beyond
iv.	Operation and maintenance of GIP on 24x7 basis	On regular basis
v.	Retrieving critics, comments and feedback from different users	On regular basis

11. Progress:

The portal is being developed as per the sitemap (Fig. 1) shown below:


Ganga Information Portal
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ONGOING STUDIES

EXTERNAL RESEARCH PROJECT: NIH-E/WRS/2015/11

1. Thrust Area under XII five year Plan

2. Project team:

a. Project Investigator Mr. L. N. Thakural, Sc-C, PI
b. Co-PI Project Co-Investigator(s) Mr. D. S. Rathore, Sc-F
Dr. Surjeet Singh, Sc-D;
Mr. Tanvear Ahmad, Sc-B
Dr. Sanjay Kumar Jain, Sc-G,
Dr. Sharad Kumar Jain, Sc-G

3. Title of the Project - Study of hydrological changes in selected watersheds in view of climate change in India.

4. Objectives-

- Development of database related to hydro-meteorological data.
- Long-term spatio-temporal analysis of hydro-meteorological variables.
- Assessment of variation in surface water and groundwater availability.
- Spatial variation of Ground water levels.
- Drought characterization.
- Climate change scenarios/analysis.
- Inter-comparison of water resources variability in selected basins and suggestions for IWRM.

5. Present state-of-art

The climate of earth has never been stable for any extended period but varying naturally on all time scales. Climate change has greatly affected the characteristics of climatic variables globally. These changes are not uniform but vary from place to place or region to region. Probable climate change and its perilous impacts on the hydrologic system pose a threat to global fresh water resources and aquatic ecosystems worldwide. The present study is envisaged in this context to take up the study on the assessment of hydrological changes in different watersheds in India under changing environment.

6. Methodology

- Literature survey on the guidelines and pre-requisites for the selection of watersheds.
- GIS database development.
- Field visits for ground truth and data collection of exiting hydro-meteorological and groundwater related data and processing of data.
- Spatio-temporal analysis of hydro-meteorological data using parametric and non-parametric approaches.
- Application of lumped conceptual rainfall-runoff model (NAM) for assessment of surface and ground water availability.
- Computation of SPI, hydrological drought indices, analysis of change in rainy days.
- Downscaling of meteorological data, generation of climatic scenarios based on IPCC-SRES using actual data
- Impact of climate change on streamflow using statistically downscaled data for each catchment

- Inter-comparison of watersheds and suggestion for irrigation water management.

7. Research outcome from the project

The outcome of the study will help in assessment of water resources availability and impact of climate change at basin scale.

8. Cost estimate:

a. Total cost of the project : Rs. 44.30 Lakh
b. Source of funding : NIH
c. Sub Headwise abstract of the cost

S.No.	Sub-head	Amount (in Rupees)
1.	Salary	9,00,000
2.	Travelling expenditure	20,00,000
3.	Infrastructure/Equipment	30,000
4.	Experimental charges	Nil
5.	Misc. expenditure	15,00,000
	Grand Total:	**44,30,000**

9. Quarterly Break up of cost estimate for each year

Year: 2015-16

S.No.	Sub-head	Amount (in Rupees)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Salary	75,000	75,000	75,000	75,000
2.	Travelling expenditure	3,00,000	3,00,000	3,00,000	3,00,000
3.	Infrastructure/Equipment	30,000	-		-
4.	Experimental charges	-	-	-	-
5.	Misc. expenditure Hydro-meteorological Data and Satellite Data Miscellaneous	- -	5,00,000 - 1,00,000	5,00,000 -	- -
	Sub- Total:	4,05,000	9,75,000	8,75,000	3,75,000
	Grand Total	**26,30,000**			

Year: 2016-17

S.No.	Sub-head	Amount (in Rupees)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Salary	75,000	75,000	75,000	75,000
2.	Travelling expenditure	2,00,000	2,00,000	1,00,000	
3.	Infrastructure/Equipment	-	-	-	-
4.	Experimental charges	-	-	-	-
5.	Misc. expenditure Hydro-meteorological Data and Satellite Data Miscellaneous	- - 1,00,000	- - -	- - 50,000	- - -
	Sub- Total:	3,75,000	2,75,000	2,25,000	75,000
	Grand Total	**9,50,000**			

10. Work Schedule:

a. Date of commencement of the project: April 2015
b. Duration of the project: 3 Years
c. Stages of work and milestone:

S. No.	Work Element	First Year	Second Year	Third Year
1.	Literature survey and Data collection, selection of watersheds	*		
2.	Processing and analysis of hydrometereological data, GIS database development,	*	*	
3.	Assessment of variation in surface water		*	
4.	Ground water variation, Drought characterization		*	
6.	Climate change, Inter-comparison of water resources variability in selected basins and suggestions for IWRM.		*	*
7.	Preparation of Final report			*

11. Progress of Work

Four different watersheds located in different climatic regions namely Dhadhar river basin (Gujarat), Ramganga up to Kalagarh (Uttarakhand), Bina River basin (M.P) and Chaliyar river basin (Kerala) as shown in Figure 1 have been selected for the present study. Most of the hydro-meteorological data viz. daily rainfall, daily temperature, humidity, and discharge pertaining to these river basins have been collected. The data entry work is in progress for Ramganga basin. Flow data is awaited for the Dhadhar basin. The data analysis of the collected data is under progress. The digital elevation model data of SRTM version 4.1 for the study basins have been downloaded from the internet and processed. In the first phase of analysis, ARCGIS 9.3 software has been used to delineate drainage networks and watershed boundaries for the four watersheds under the study.

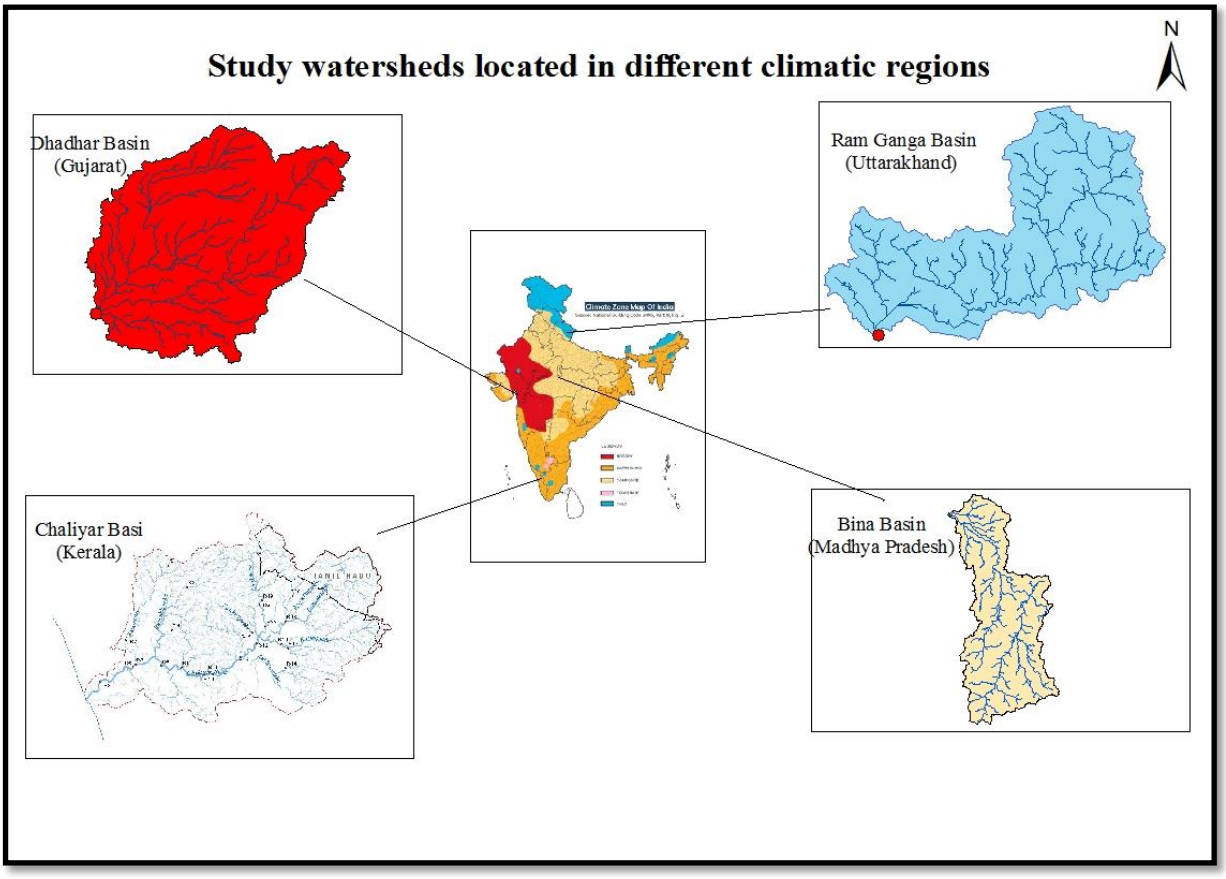


Figure 1: Study watersheds located in different climate regions of India

NEW STUDIES

INTERNAL RESEARCH PROJECT: NIH-E/WRS/2015/01

1. Thrust Area under XII five year Plan

Sustainable water systems management: Adaptation of hydro-system to climate change

2. Project team:

a. Project Investigator — Dr. P. K. Singh, Sc-C, PI

b. Co-PI Project Co-Investigator(s) — Dr. Sharad Kumar Jain, Sc-G & Head; Dr. Sanjay Kumar Jain, Sc-G; Er. Manish Nema, Sc-C

3. Title of the Project - Studies on Temporal Variation of Sediment Yield in Hilly Watershed of Upper Ganga Basin, Uttarakhand

4. Objectives-

1. To estimate temporal variation of sediment yield and its total volume during a storm event.
2. To explore impacts of basin geo-morphology on time distributed sediment yield and its total volume.
3. To explore impacts of soil moisture accounting (SMA) on temporal distribution of sediment yield and its total volume.

5. Present state-of-art

Sediment yield studies are important for various soil and water conservation planning processes, viz., reservoir sedimentation analysis, studies on river morphology changes and river bed siltation, and agricultural project planning. Sediment yield from a watershed is the output form of an erosion process, and is difficult to estimate as it arises from a complex interaction of various hydro-geological processes. In spite of extensive studies on the erosion process and sediment transport modeling, there exists a lack of universally accepted sediment yield formulae (Bogardi et al., 1986; Kothyari et al., 1996). Sediment-related problems can occur upstream and downstream and vary widely from one site to another. A major effect of sedimentation is the loss of storage capacity, which can have a serious impact on water resources development by reducing water supply, hydropower production, the supply of irrigation water, and the effectiveness of flood control schemes (Wang et al., 2005).

In spite of extensive studies on the erosion process and sediment transport modeling, there exists a lack of universally accepted sediment yield formulae (Bogardi et al., 1986; Kothyari et al., 1996). Erosion and sediment yield models are broadly classified into three categories as empirical models, conceptual models, and process-based models. More recently Merritt et al. (2003) and Aksoy and Kavvas (2005) provided a good review of approaches to model sediment transport and erosion, including several published models. There are very limited studies dealing with estimation of sediment yield its distribution with time in hilly watersheds. However, no such study has been conducted previously for Upper Ganga Basin (UGB).

6. Methodology

Accurate and reliable predictions are becoming extremely important to civic society, with local and regional governments increasingly being asked to make independent judgments about actions required to prevent and manage natural disasters, and manage the natural environment around them and their water resources in a sustainable manner.

According to Bennett (1974), the major part of the annual sediment discharge is transported in a short period of time by a few storms during which the discharge of the stream is continuously changing. Therefore temporal variations of the stream sediment discharge (sediment graph) studies are very important (Chen and Kuo, 1986; Singh et al., 2008), particularly from un-gauged catchments.

Model Development:

a. In this study, simple mathematical models will be developed to estimate sediment yield and its distribution with time using (i) $C = S_r$; concept; where $C = Q/(P-I_a)$ and $S_r = (F/S)$ (C= runoff coefficient, Q = runoff, P = rainfall, I_a = initial abstractions, F = cumulative infiltration, and S = potential maximum retention) (Mishra and Singh, 2003); (ii) Power Law (Novotny and Olem, 1994) $DR = \alpha C^{\beta}$; where DR = sediment delivery ratio, and IUSG model (Rendon-Herrero, 1978; Kumar and Rastogi, 1987 and Singh et al. 2008; Bhunya et al., 2010; Lee and Yang, 2010).

b. The study will also attempt to explore and establish relationship between basin geo-morphology and time distributed sediment yield.

c. Lastly, it would be extremely interesting to explore possible inter-relationship between soil moisture accounting (SMA) and sediment yield and basin geo-morphology. The study will also make use of remote sensing and geographic information system (GIS) techniques.

Study Area:

The above methodology will be applied to the small hilly Hinvel watershed in UGB (catchment area 120 km^2). The watershed has been taken by WRS Div. for establishment of advanced hydrological instrumentation and measurements to characterize various hydro-meteorological processes and their inter relationships.

In this study, instrumentation setups will be established for measuring suspended sediment concentration (SSC) on storm and daily basis. Depth Integrating Sediment Sampler (US DH 48/ 59) will be used to measure SSC. Digital hand held water velocity meters will be used to measure the stream velocity and discharge. Probes will be used to measure temperature, dissolved oxygen (DO), biological oxygen demand (BOD), pH, conductivity, total dissolved solids (TDS), etc.

7. Research outcome from the project

a. Temporal distribution of sediment yield and its total volume on storm basis.
b. Impacts of basin geo-morphology on sediment yield and its distribution with time.

c. Impacts of SMA on sediment yield and distribution with time.

8. Cost estimate

a. Total cost of the project: Rs. 8,20,000.00
b. Source of funding: NIH
c. Sub Head wise abstract of the cost: As below

S. N.	Sub-head	Amount (Rs.)
1.	Salary	4,00,000.00
2.	Travelling expenditure	80,000.00
3.	Infrastructure/ Equipment	3,00,000.00
4.	Experimental charges	0.00
5.	Misc. expenditure	40,000.00
	Grand Total:	8,20,000.00

a. Justification for Sub-head-wise abstract of the cost

Salary head accounts for involvement of minimum 1 semi-skilled labour @Rs. 15000/-month. Travelling expenditure include visit to Hinvel watershed.

Misc. expenditure for an amount of Rs.10000.00 per quarter has been considered.

9. Quarterly Break up of cost estimate for each year

Year: 2015-16

Sl. No.	Sub-head	Amount (in Rs.)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Salary	45000.00	45000.00	45000.00	45000.00
2.	Travelling expenditure	10000.00	10000.00	10000.00	10000.00
3.	Infrastructure/Equipment	0.00	150000.00	150000.00	0.00
4.	Experimental charges	0.00	0.00	0.00	0.00
5.	Misc. expenditure	10000.00	10000.00	10000.00	10000.00
	Sub- Total:	65000.00	215000.00	215000.00	65000.00
	Grand Total:	Rs. 5,60,000.00			

10. Work schedule

a. Probable date of commencement of the project: January 01, 2016
b. Duration of the project: 2 years
c. Stages of work and milestone: Shown below

Project Year	Jan 2016-Dec 2017				Jan 2017-Dec 2018			
Project Quarter	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
A. Concept Building and understanding of study basin								
B. Procurement of Instruments								
C. Establishment of Instruments								

D. Data gathering, Preparation & Synthesis								
E. Modelling Time distributed sediment yield: Model Development								
F. Model Application and Testing								
G. Incorporation of Geo-morphological parameters in sediment yield model								
H. Model Application and Testing								
I. Incorporation of soil moisture accounting (SMA) procedure in sediment yield model								
J. Model Application and Testing								
K. Sensitivity Analysis of the models								
L. Final Report Preparation								

11.	Progress till date:	NA

WORK PROGRAMME FOR YEAR 2015-2016

SN	Title of Project/Study, Study Team	Duration
1.	**Study- 1 (RMOD/2015-16/TS-1)** 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 Rajesh Singh	DOS: Apr 2013 DOC: March 2016 (Ongoing study)
2.	**Study- 2 (RMOD/2015-16/TS-2**) 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 (Ongoing; study-extension sought upto January 2016)
3.	**Study-34 (RMOD/2015-16/TS-3)** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** V C Goyal (PBS Leader), Jyoti Patil and R V Kale **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna)	DOS: Apr 2015 DOC: Mar 2017 (Ongoing study)

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-Jan 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**

Study- 1 (RMOD/2015-16/TS-1)

1. **Title of the Study:** Water Conservation And Management In Ibrahimpur Masahi Village Of Haridwar District (Uttarakhand)

2. **Study Group:**

Investigators: Omkar Singh, V.C. Goyal, C.K. Jain, J.V. Tyagi and Rajesh Singh
Scientific/Technical Staff Subhash Kichlu, 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, 2016
6. **Duration of the Study:** 3 years
7. **Study Objectives:**
   - Assessment of water demand in the study area
   - Assessment of water availability in the study area
   - Assessment of water quality in the study area & eutrophication status of ponds
   - Preparation of water conservation plan for the study area

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 face 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 peoples. 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 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. The village level data on demography, dwelling amenities, public buildings, etc. was also collected door to door during surveys. 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 would 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 surface runoff estimation is proposed using USDA-SCS curve number technique (SCS, 1972). 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 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:

$$DWR_d\ (m^3/day) = (P_{rural} \times 40 + P_{urban} \times 135) \times 10^{-3}$$
$$DWR_m(m^3/month) = (P_{rural} \times 40 + P_{urban} \times 135) \times 10^{-3} \times 30$$
$$DWR_a(m^3/annum) = (P_{rural} \times 40 + P_{urban} \times 135) \times 10^{-3} \times 365$$

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):

$$LWR_d\ (m^3/day) = \{C \times 85 + B \times 85 + B_o \times 85 + S \times 10 + G \times 10 + S_W \times 15 + P \times 0.40\} \times 10^{-3}$$
$$LWR_m\ (m^3/month) = \{C \times 85 + B \times 85 + B_o \times 85 + S \times 10 + G \times 10 + S_W \times 15 + P \times 0.40\} \times 10^{-3} \times 30$$
$$LWR_a\ (m^3/yr) = \{C \times 85 + B \times 85 + B_o \times 85 + S \times 10 + G \times 10 + S_W \times 15 + P \times 0.40\} \times 10^{-3} \times 365$$

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 no. of 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.

Preparation of Water Conservation Plan: The water conservation plan would be suggested on the basis of village level data on demography, dwelling amenities, public buildings, water availability, sectoral water demands & water uses, etc. Accordingly, rainwater harvesting potential in the study area would be carried out as below:

- Household monthly harvested rainwater & balance after flushing
- Household monthly harvested rainwater & balance after flushing & laundry (combined)
- Rainwater harvesting potential of village ponds
- Monthly roof top water harvesting potential of schools/govt. buildings

The volume of rainwater that could be harvested per household per month would be estimated Eq. given by Ghisi et al., 2006 as below (Aladenola and Adeboye, 2010; Ishaku, et al., 2013):

$$VR = \frac{R.HRA.RC}{1000}$$

Where, VR= monthly volume of rainwater per household (m^3), R= monthly rainfall depth (mm), HRA= household roof area (m^2), and RC= runoff coefficient (dimensionless). The basic monthly balance would be estimated by subtracting monthly water demand from collected monthly rainwater and is expressed as below:

$$Wa = Iv + Vc - Vu$$

Where, Wa= water available, Iv=initial volume in storage, Vc=volume collected and Vu= volume used.

10. Timeline:

S. N.	Major Activities	2013-14				2014-15				2015-16			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	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, survey of ponds etc.)												
5.	Analysis of data for assessment of water demand, availability, Water Quality, etc.												
6.	Preparation of water conservation plan, eutrophication of ponds												
7.	Report (s) preparation												

11. Objectives and achievements:

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).
	• 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(March, 2015). • The soil texture and soil moisture data was analysed for the study area (March, 2015). • Drainage pattern was prepared using DEM (March, 2015). • Landuse/Landcover map of Ibrahimpur Masahi village was prepared using google earth images. • Groundwater utilization data pertaining to Hand pumps and Tub wells used for drinking and irrigation purposes was collected in the study area.
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 (March, 2015). • Water quality parameters (Secchi depth, phosphate, etc.) necessary for Eutrophication analysis of ponds was monitored. Quality of wastewater input to the ponds was also

	monitored.
iv) Preparation of water conservation plan for the identified village (s)	• Bathymetric survey of village pond at Masahi was completed. • Accordingly, the capacity estimation of the village pond (s) was revised for RWH potential. • Necessary data at village level pertaining to demography, dwelling amenities, public buildings, etc. was collected door to door in all sub-villages of Ibrahimpur Masahi for preparing a water conservation plan in the study.

12. Recommendation / Suggestion:

Recommendation / Suggestion/Queries	**Action Taken**
Chairman desired to know about utilization of boat for bathymetric survey of pond (s) in the villages.	Complied

13. Analysis & Results: The water demand for domestic, livestock and agricultural uses has already been estimated for the Ibrahimpur Masahi Revenue Village. 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 also completed. The works carried out during reporting period include: (i) Preparation of village boundary map of Ibrahimpur Masahi, (ii) Landuse/Landcover map of village, (iii) Water quality investigations from different sources (drains, ponds, surrounding hand pumps), (iv) Bathymetric survey of village pond at Masahi, (v) Data collection from village (s) for rainwater harvesting potential of the study area.

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:

- Preparation of water conservation plan for the Ibrahimpur Masahi village.

Study- 2 (RMOD/2015-16/TS-2)

1. **Title of the Study:** Customization of WEAP model for application in Ur river watershed in Tikamgarh district of Bundelkhand region.
2. **Study Group**:

Project Investigator Dr**.** Ravindra V. Kale, Scientist 'B', NIH
Project Co-investigator Er. T. Thomas, Sc. D, RC, NIH Bhopal Dr. Jyoti Patil, Sc. B, RMOD, NIH Roorkee
Scientific/Technical Staff Mr. Rajesh Agrawal, SRA

3. **Type of Study**: TIFAC Sponsored study
4. **Nature of Study:** Applied Work
5. **Date of start:** 01.04.2014
6. **Scheduled date of completion:** 30.09.2015 [Extension of four month (upto 31st January 2016) is required]
7. **Duration of the Study:** 18 Months
8. **Study 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) 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

9. **Statement of problem:**

The Bundelkhand region in Central India is under limelight because of the continuous drought situation resulting in acute water and power shortages and large-scale migration of local population elsewhere in search of livelihood. The water resources management under drought scenario is a challenging task for the decision makers and planners since it is not at all possible to avoid droughts leading to widespread water scarcity. The phenomenon of drought coupled with the impacts of the climate change could prove to be disastrous for the fragile ecosystems and economy of the region. To improve the water situation in the region, it is felt that an integrated approach to water and waste water management has to be undertaken. The water management approach has to be built around the concept of efficient management and sustainability (quality and quantity), and building of institutional systems at various levels (village, block, district levels) for community based management of water challenges. Prior to designing any interventions, it is important that the current status and its driving forces are well understood. In order to evaluate current status of water resources availability and its planning based on various demand sites priority WEAP based DSS system may be very helpful. As,

WEAP is a robust tool for assessment, management and planning of water resources where it simulates hydrologic pattern based on climatic input. Thus, the development of a Decision Support System (DSS) linking water resources with livelihood issues and future climate change impacts will provide the decision makers to decide upon alternate management options under various scenarios.

This study is undertaken with aim to prepare required input data structure to customize WEAP model for Ur River watershed in order evaluate currently available water resources and management of demand and supply requirements of different socio-economic activities. Subsequently, customized WEAP model will be tested to assess its ability to be used as a simulation tool to perform different types of scenario analysis studies.

10. **Approved Action Plan / Methodology**

i. Collection and processing of input data such as hydro-metrological data, ground water data, reservoir storage data, LULC data, Soil data, satellite based spatial and temporal, demographic and live stock data, crop and irrigation data, crop production and market value data for customization of WEAP model.
ii. Execution and testing of WEAP model simulations.
iii. Generation of various water management scenarios.

Methodology:

This study intended to customize the Water evaluation and Planning (WEAP) model (Fig. 1) by linking the Integrated Water Resource Management (IWRM) and hydrological inputs with livelihood issues in Ur River catchment in Tikamgarh District (M.P.).

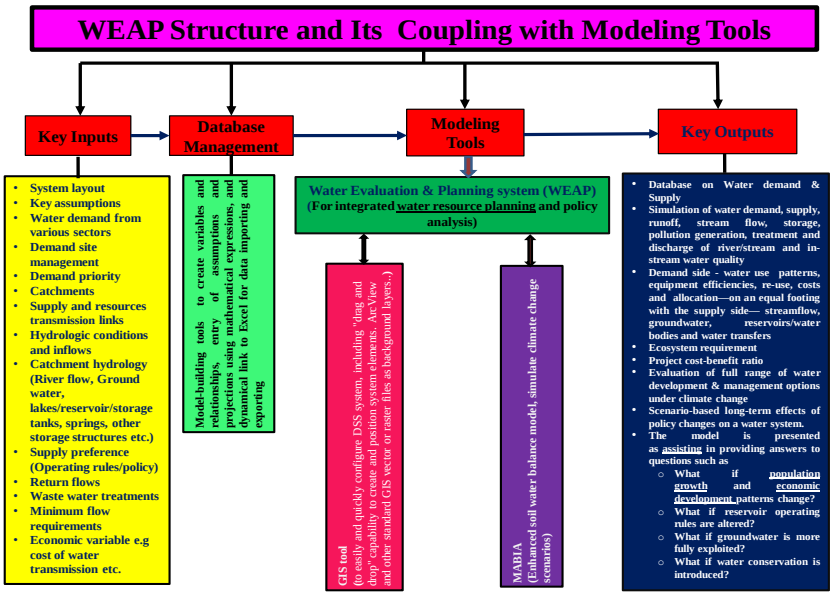


Figure 1. The WEAP model structure along with its coupling with other modeling tools to customize it for the Ur River catchment.

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.

11. **Timeline:**

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**	

12. **Objectives and achievement during last six months**

Objectives	Achievements
Identification of site and Instrumentation at the identified	• Identification of site and instrumentation at the identified site has been completed. The

site	measurements of hydro-metrological parameters at Tikamgarh and discharge of Ur River at two sites has been carried out from Sept. 2014 – March 2015.
Collection of hydro meteorological data, satellite images, thematic maps etc.	• The hydro-metrological data available with different government agencies has been collected. The high resolution data (Cartosat data) has been acquired from NRSC and 2.5 m × 2.5 m DEM has been prepared. All the spatial data processing in GIS including the estimation of tank storage capacity is completed.
Compilation and verification of hydro-mertological data, baseline survey data, census data and other qualitative data	• Compilation and verification of most of the hydro-metrological data, baseline survey data, census data and other qualitative data has been completed.
Preparation of input data for WEAP model	• Climatic-data has been prepared. • Kharif and Rabi cropping area as well as cropping pattern data, Crop library data, soil library data, crop production and market price data has been updated. • Domestic water demand data has been prepared. • Surface runoff, reservoir storage capacity and initial storages and ground water data is prepared.
Customization of WEAP for Ur River catchment and validation of model with observed data	• During last working meeting the schematic view has been prepared by dividing whole Ur River watershed into 18 sub-watersheds. However, due to limitation of observed runoff data and other input data availability at finer scale for the model calibration and validation, the new schematic has been prepared with consideration of 8 sub watersheds. • Various links such as rivers, demand sites, agricultural watersheds, ground water nodes and transmission links has been prepared. • Providing input data for various links in model framework and testing of the model results is under progress.

13. **Recommendation / Suggestion**

Recommendation / Suggestion	Action Taken
1. No Specific comments	N.A.

14. **Analysis & Results**

- In this study Ur River watershed having area of 990.37 km^2 is selected for the customization of WEAP based DSS for the IWRM. The watershed ID and watershed code of 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 Fig. 2. Further, Figure 3 shows the details of existing streams, reservoirs/dams, micro-watersheds and tehsil areas covered by the study area.

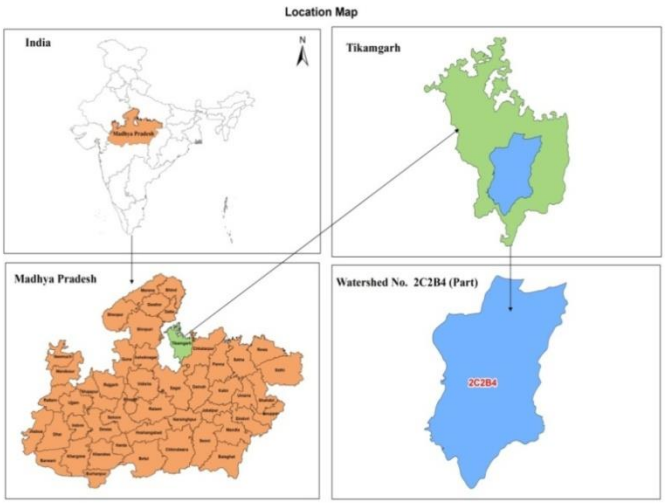


Figure 2. Location map of the Ur River catchment in Tikamgarh District (M.P.).

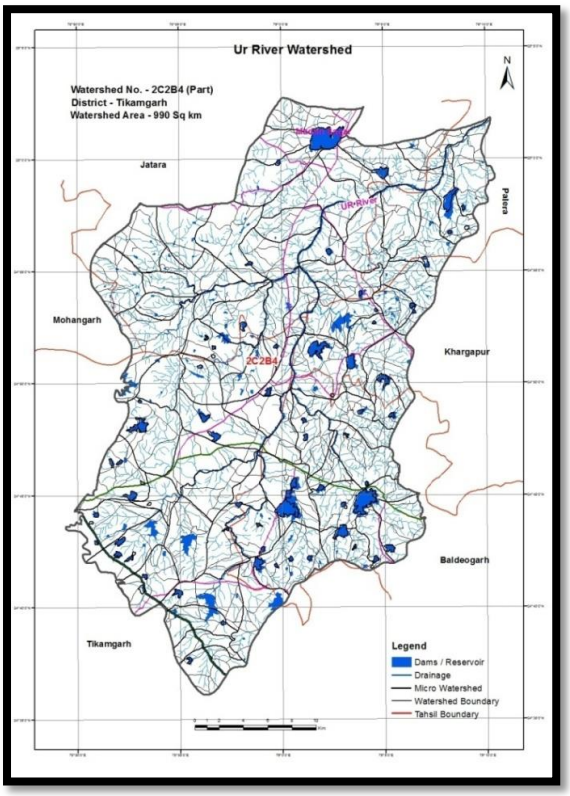


Figure 3. Map of study area showing the details of existing streams, reservoirs/dams, micro watersheds and tahsil boundaries.

• 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, computerization and processing of the rainfall and other statistical data from various organizations at Tikamgarh (completed). The status of data collection and processing to be used as an input for WEAP model customization is shown in following Table 1.

Table 1. Input data for WEAP model customization and its status on 18.02.2015

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]	Data shown in bold is Collected from CGWB. The available ground water level Data from state ground water Dept. is also Collected.
2.	**Reservoir storage data**	• Storage capacity (MCM) • Initial Storage (MCM) • Net Inflow	Irrigation Department/ WRD	Available data collected. There are numbers of lakes/tanks are located in Ur river watershed for which storage capacity data, initial storage and net inflow data is not available with any Government department. Therefore, attempt has been made to extract the required data by using RS and GIS techniques.
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	Daily Daily Daily Daily Monthly	Collection of available hydrological parameters data is completed. No stream flow records are available and hence measurement of stream discharge data is carried out

		water bodies • **Location of wells and water harvesting structures**	Monthly [Data shown in bold is the important data if only demand and supply has to be meet out]	with advanced instruments from Sept./Oct., 2014 – March 2015. Measurement of Water level data in the selected lakes is measured during this period.
4.	**Land Use Data**	• Land use/Land cover map (.shp file) • Total Land Area (ha) • Share of Land Area for different crops • Land capability • Net Sown Area for Crops (Kharip/Rabi/Dual season crop area)	GIS/SAC Year 2010 One time Yearly season-wise data	LULC map and Land capability map prepared. Collection of crop data selected sub-watershed has been completed.
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]	DEM having resolution 2.5 m × 2.5 m has been prepared by MPCST. All other maps and .shp files are prepared using high resolution DEM.
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 ii. Mid season Stage v. 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) 3. FAO56 Irrigation and Drainage – Page No.56 Crop evapo-transpiration 4. Literature [Crop specific information, Season wise]	Data collected

7.	**Soil properties**	• Soil type and its properties i. Saturation ii. Field capacity ii. Coarse fragment v. 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 • Solar radiation • Pan evaporation rate	-Daily time series data is required from base year to ending year. Source:- Indian Meteorological Department / KVK	Data collection completed.
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	Domestic water demand estimated.
12.	**Demographic and Other Parameters**	• Population density • Population growth rate • Urbanisation rate		Data collection completed.

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

• Following consent with district collector, Tikamgarh, a contract has been given to M/s Virtual industries Pvt. Ltd. to install various instruments and

equipment to collect following hydrological and climatic parameters on hourly and/or daily basis and continuous monitoring is carried out from Sept. 2014-March 2015.

- 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.

• 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 Fig. 4 in the study area based on the various crop-soil combinations.

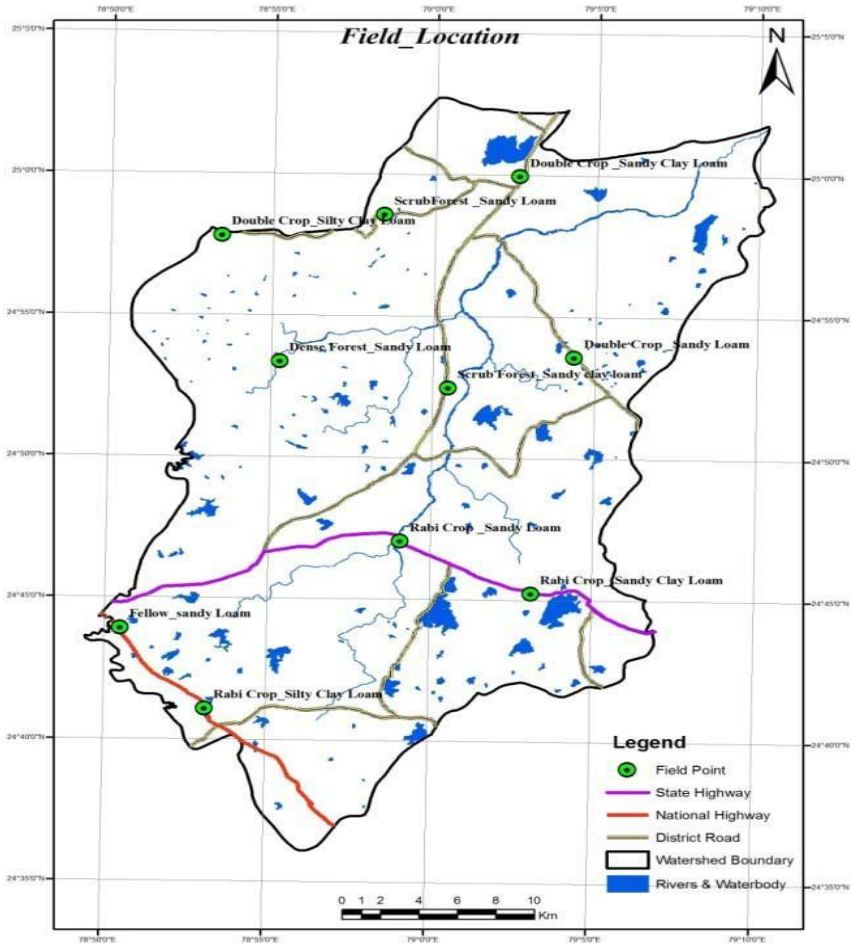
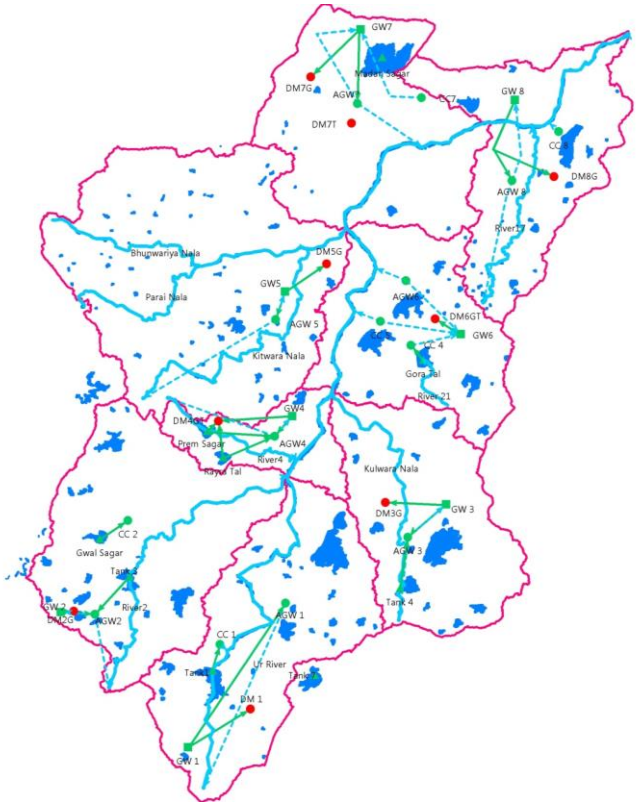


Figure 4 : Location of sites for infiltration and hydraulic conductivity tests.

- Before 42th working meeting, a schematic view required in the WEAP model customization was prepared by dividing the whole watershed into 18 sub-watersheds. Subsequently, the required input data using GIS has been extracted as per model requirement. However, due to limitation of input data requirement and in order to reduce the uncertainty in model prediction, it decided to divide the whole

watershed into 8 sub-watershed based on topographic, morphologic, socio-economic and LULC conditions. Subsequently, the required input data using GIS has been extracted as per modified model requirement. The prepared schematic is shown in the following Fig.



- Based on this schematic view, the required input data has been prepared for various demand nodes, agriculture catchments, and transmission links and entered into the Data framework. Due to lack of observed discharge data for Ur River, the runoff from each sub-watershed has been computed using standard SCS-CN method and the obtained results are shown in Fig. 5. Various irrigation management scenarios have been prepared to analyze the different alternatives in irrigation water management. The preliminary results has been achieved which will be discussed in details during WGM.
- During 25/04/2015 to 20/05/2015, a study tour to IIASA, Laxenburg Austria has been carried out along with Dr. V. C. Goyal, Scientist G and Head RMOD. During the stay at IIASA, the crop and soil data has been prepared for model in discussion with IIASA scientist also the discussion on scenario development in WEAp model has been carried out.
- During the 16/06/2015 to 20/06/2015 2nd stakeholder workshop under TIFAC Sponsored project has been organized, the WEAP model results are discussed with stakeholders and the attempt has been made to incorporate their appropriate suggestions in the WEAP model.

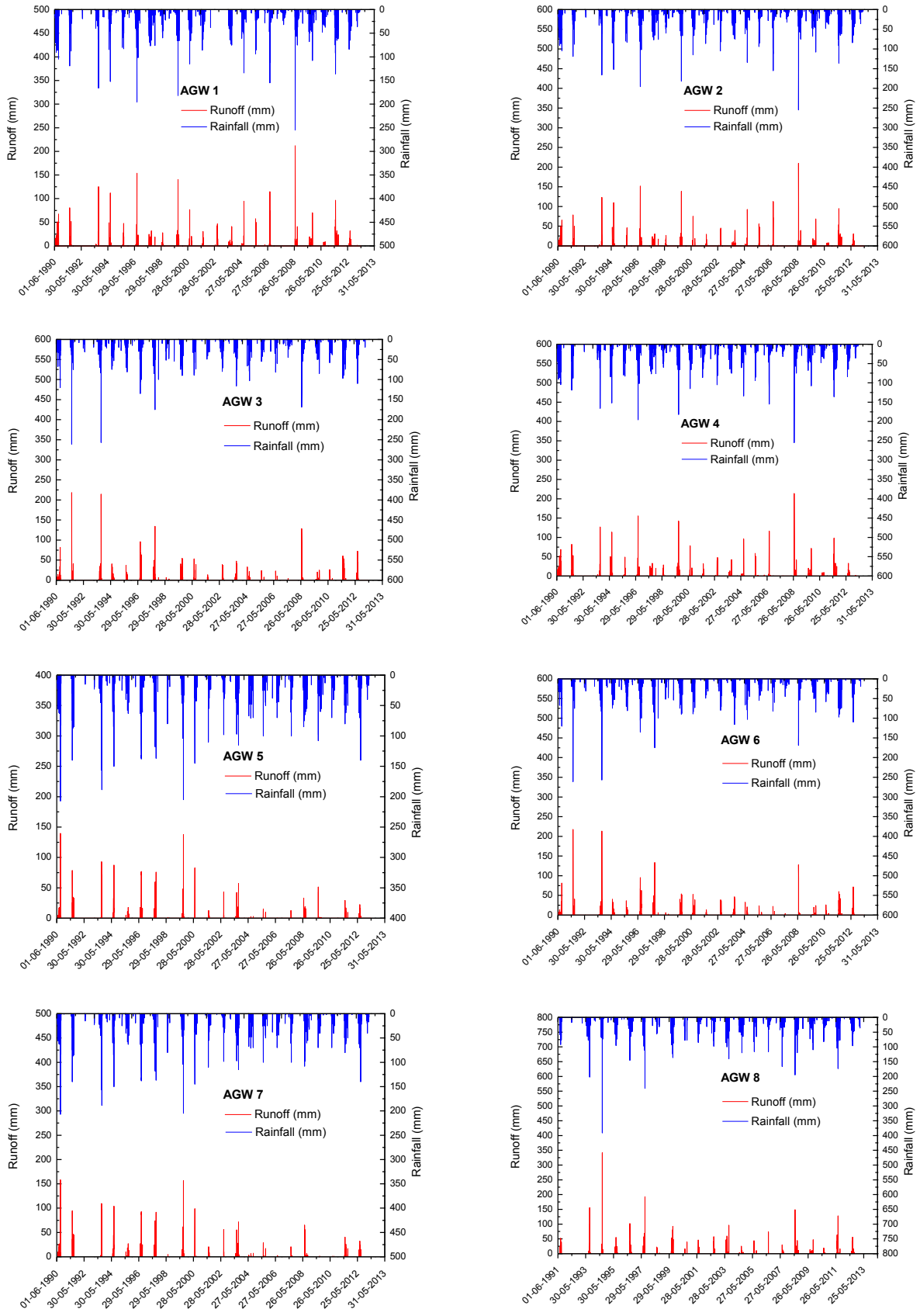


Figure 5. Rainfall-runoff hydrographs for each sub-watershed.

TASK TO BE COMPLETED DURING NEXT FOUR MONTHS

- Calibration and Validation of WEAP model using computed SCS-CN based discharge hydrograph.
- Checking of model results with incorporation of various scenarios.
- Impact of climate change scenarios (after collected the climate change data from IIASA) will be incorporated in WEAP model to plan irrigation water demands and other water use demands in Ur river catchment.
- Preparation of final report.

15. **End Users / Beneficiaries of the study** **:** State Govt. policy Planners/stake holders
16. **Deliverables** **:** Technical report& research papers
17. **Major items of equipment procured** **: High Resolution spatial data/software**
18. **Lab facilities used during the study** **: MPCST Bhopal and RC, NIH Bhopal**
19. **Data procured or generated during the study** **:** Metrological data from IMD, Ur River discharge data, lakes water level data, AWS data, infiltration data
20. **Study Benefits / Impacts**

Measurable indicators	Achievements
Customization of WEAP based DSS	Under progress

21. **Involvement of end users/beneficiaries: State government/ local stakeholders**
22. **Specific linkage with Institution and /or end users/beneficiaries** : MPCST/state Govt. Departments
23. **Shortcoming/Difficulties :** Non-availability of stream flow discharge data and water tanks storage information
24. **Future Plan:** The customized WEAP model will be used to development Decision Support System (DSS) for linking water resources with livelihood issues and future climate change impacts to assist the decision makers to decide upon alternate management options under various scenarios.

Study- 3 (RMOD/2015-16/TS-3)

1. **Title of the Study:** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme
2. **Project team:**
    a) **Project Investigator:** V C Goyal (PBS Leader)
    b) **Project Co-Investigator(s):** Jyoti Patil and R V Kale (RMOD); Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna), RC-Jammu
3. **Type of Study:** Internal
4. **Date of start:** 01.04.2015
5. **Scheduled date of completion:** 31.03.2017
6. **Duration of the Study:** 2 Years
7. **Study Objectives:**
    - The main objective of the study is to set up the WEAP model for 4 sub-basins under the PBS Programme (Bina in MP; Zuari in Goa; Yerakalva in AP and Mahi in Bihar).
8. **Statement of the Problem:**

The Water Evaluation and Planning System (WEAP) contain components that allow the appraisal of water management strategies at basin level with economic values. It has been developed by the Stockholm Environmental Institute (SEI) as a decision support tool for water resources management (www.weap21.org). It is being applied particularly in regions, which are characterized by water scarcity and increasing demands. In many basins, the groundwater extractions exceed the natural recharge resulting in a deterioration of the water qualities and worsening the water shortage. The application of integrated water management strategies (IWRM), including water reuse, artificial ground water recharge, use of brackish water, storage of natural and reclaimed water, demand measures and improved water allocation among competing water uses, becomes increasingly necessary.

The economic components of WEAP allow the calculation of costs for demand notes, transmission links, treatment plants and reservoirs. Moreover, the beneficial impacts of increase in water availability for different demand sites can be evaluated in economic terms. By creating suitable indicators the economic losses of unmet demands and the environmental costs of low river flows can be evaluated as well. WEAP offers the possibility to perform cost-benefit analyses of alternative measures to tackle water problems. For instance, the construction of a reservoir or of a new treatment technology at a demand node to mitigate water shortage can be compared in terms of net present values. The economic net benefits of investments on annual basis can be calculated for different demand nodes. These calculations methods serve to find out the most appropriate IWRM strategy at basin level. Furthermore, various financing options under different loan conditions and pricing policies can be considered.

WEAP was applied successfully to model the hydrological features and water management strategies at many basins and it is being developed further. An example is the co-operation between the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) and the German Federal Institute for Geosciences and Natural Resources (BGR) (www.acsad-bgr.org). A further example is the research project ‘Integrated Water Resource Management in the Lower Jordan

Rift Valley (SMART)', funded by the German Ministry of Education and Research (BMBF) (www.iwrm-smart.org).

9. **Methodology**

Customization of the WEAP model will be carried out for the respective sub-basins on a daily/monthly time step. First, a database will be prepared covering the required hydrologic, demographic and socio-cultural data, to be used with the model. Then, a draft schematic of the WEAP model will be prepared defining the demand and supply nodes, etc. The draft WEAP schematic will be discussed with the local stakeholders, and their views will be incorporated in the final model set up. Results from the WEAP model analysis will be used to prepare an integrated water management plan for the 4 sub-basins. Next, the integrated water management plan will be shared with the local stakeholders in the form of a training workshop.

10. **Timeline**:

S. N.	**Work Element/ Milestone**	**2015-16**				**2016-2017**			
		1st Qtr	**2nd Qtr**	**3rd Qtr**	**4th Qtr**	**1st Qtr**	**2nd Qtr**	**3rd Qtr**	**4th Qtr**
1	Creation of database	√	√						
2	Draft WEAP model set up			√	√				
3	Stakeholders' meeting				√	√			
4	Finalization of WEAP model set up						√	√	
5	Training workshop								√

11. **Objective and achievement during last six months:**

Objective	**Achievement**
Creation of database	Data availability of each sub-basin is being summarized

12. **Recommendation / Suggestion:** No Specific comments
13. **Analysis & Results:**
14. **End Users / Beneficiaries of the study:** Water Resources Planners of the respective sub-basins
15. **Deliverables:** Training workshop for the stakeholders
16. **Major items of equipment procured:** Nil
17. **Lab facilities used during the study:** Nil
18. **Data procured or generated during the study:** None
19. **Study Benefits / Impacts:**
20. **Involvement of end users/beneficiaries:** Local stakeholders
21. **Specific linkage with Institution and /or end users/beneficiaries:** Various line departments (KVKs, Irrigation, WRD, Agriculture, Industry)
22. **Shortcoming/Difficulties:**
23. **Future Plan:**

WEAP model in the 4 sub-basins will be used in preparation of integrated water management plans for each sub-basin.