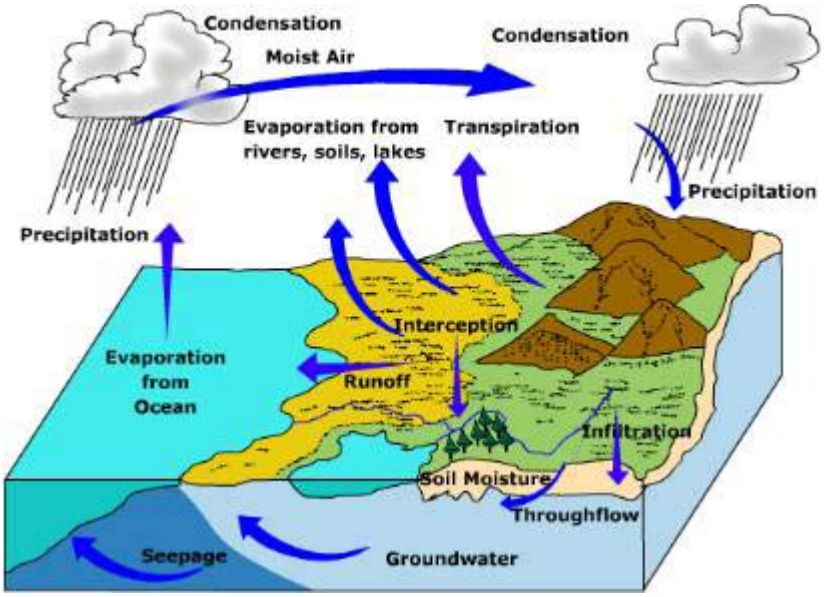
AGENDA AND AGENDA NOTES FOR THE 38th MEETING OF THE WORKING GROUP OF NIH

APRIL 3-4, 2013
AT 1100 HRS



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NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

AGENDA AND AGENDA NOTES FOR THE 38th MEETING OF THE WORKING GROUP OF NIH

AGENDA ITEMS

ITEM NO. 38.1 Opening Remarks by the Chairman

ITEM NO. 38.2 Confirmation of the minutes of 37th meeting of the Working Group

The 37th meeting of the Working Group was held during October 29-30, 2012. The minutes of the meeting were circulated to all the members and invitees vide letter No. RMOD/37th WG/NIH/11 dated January 24, 2013. No comments were received on the circulated minutes. A copy of the minutes of the 37th Working Group is given in **Annexure A.**

The Working Group may please confirm the minutes.

ITEM NO.38.3 Action taken on the decisions/recommendations of the previous Working Group meeting

During the 37th 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.38.4 Presentation and discussion on the status and progress of the work programme for the year 2012-2013.

The approved Work Programme of the six Divisions of the Institute for the year 2012-13 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 2012-2013			
Division	**Studies**		**Total**
	Internally funded	Sponsored (including HP-II)	
Environmental Hydrology	02		**02**
Ground Water Hydrology	02	04	**06**
Hydrologic Investigation	05	09	**14**
Surface Water Hydrology	08		**08**
Water Resources System	06	03	**09**
Research Management & Outreach	02		**02**
Total			**41**

During the present meeting, Division-wise progress and status of the work programme for the year 2012-13 shall be presented in detail. The Working Group may please consider the progress and status of the Work Programme for the year 2012-2013.

ITEM NO. 38.5: Presentation and finalization of the work programme for the year 2013-2014.

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

The work programme has been categorized into three groups: (a) Internally funded studies, (b) Sponsored projects including Purpose Driven Studies under HP-

II, and (c) Consultancy projects. During the present meeting, Division-wise proposed work programme for the year 2013-14 shall be presented.

	No. of Studies/Projects During the Year 2013-2014					
Division	**New**		**Ongoing**		**Total**	
	Internally funded	Sponsored (including HP-II)	Internally funded	Sponsored (including HP-II)		Consultancy Projects
Environmental Hydrology	03		02		**05**	**01**
Ground Water Hydrology	02			04	**06**	**01**
Hydrologic Investigation	01	01	02	07	**11**	**02**
Surface Water Hydrology	05		05		**10**	**-**
Water Resources System	05	01	01	02	**09**	**-**
Research Management & Outreach	01		02		**03**	**-**
Total	**17**	**02**	**12**	**13**	**44**	

The Working Group may please consider the proposed Work Programme for the year 2013-2014.

ITEM NO. 38.6: Any Other Item with Permission of the Chair.

ANNEXURE – A

MINUTES OF THE 37TH MEETING OF WORKING GROUP

MINUTES OF THE
37TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING OCTOBER 29-30, 2012

The 37th meeting of the Working Group of NIH was held at NIH, Roorkee, during October 29-30, 2012 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 37.1: OPENING REMARKS BY THE CHAIRMAN

Er. R D Singh, Director, NIH, was not available due to an urgent official meeting in the Ministry of Water Resources. Dr. S K Jain, Director-in-charge, chaired the meeting. The Chairman, WG welcomed the Working Group members and the Scientists of the Institute. The Chairman then requested the Working Group members to give their general observations, suggestions and remarks on the scientific activities of the Institute. These are summarized below:

S N	Member	Suggestion(s)
1	Dr. R C Jain	▪ Pro-active approach for water resources investigations ▪ Integration of disciplines and collaboration across sectors ▪ Farmers participation ▪ Knowledge management
2	Dr. G P Juyal	▪ Studies on climate change & variability ▪ Impact assessment of landuse changes
3	Dr. V V Rao	▪ Energy balance estimation ▪ Suggested shortening of the meeting duration
4	Dr. R D Deshpande	▪ Dew water harvesting ▪ Soil aquifer treatment ▪ Thermal energy use- thermal regime of groundwater ▪ Discussion of selected studies, with grouping of common activities/studies ▪ Presentation should have more emphasis on results and interpretation
5	Dr. S N Rai	▪ Concentrate on few areas and carry out integrated studies ▪ Literature survey should be done before formulating a project/study ▪ Deliverable should be useful to the society
6	Sri Sanjeev Sharma	▪ River embankments ▪ Controlled sand querring
7	Dr. Kishore Kumar	▪ Use of ICT

8	Dr. S C R Vishwakarma	▪ Cloud burst prone area mapping
9	Prof. J S Rawat	▪ Studies related to drying up of springs and streams. ▪ Develop model for rejuvenation of streams. ▪ Studies on eco-hydrology.
10	Er. R K Khanna	▪ Organize training courses on environmental aspects of water resources development ▪ Post project evaluation of completed projects ▪ Studies should have applicability to the users ▪ Approach stakeholders & line departments
11	Dr. N B Narsimha Prasad	▪ Develop national level projects ▪ Suitability of river basin transfers ▪ Impact of sand mining on river regime ▪ Wetland hydrology ▪ Name of funding agency and cost should be mentioned for sponsored projects ▪ Need for collaboration between NIH & CWRDM

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. 37.2: CONFIRMATION OF THE MINUTES OF 36TH MEETING OF THE WORKING GROUP

The 36th meeting of the Working group was held during April 3-4, 2012. The minutes of the meeting were circulated to all the members and invitees vide letter No. RCMU/36th WG/NIH/11 dated May 7, 2012. As no comments were received on the circulated minutes, the minutes were confirmed.

ITEM No. 37.3: 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 36th working group meeting.

ITEM No. 37.4: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2012-13.

The Member-Secretary made a brief presentation outlining progress made under different studies for the work programme of 2012-13. Division wise progress on each study/project presented during the meeting is given in the next section.

ENVIRONMENTAL HYDROLOGY DIVISION

S.No.	Title of the Project/Study, Study Team, Date of Start and Completion	Status and Recommendation/Suggestion
	Research Studies	
1.	Assessment of Groundwater Quality in Hindon River Basin. Team: M.K. Sharma (PI), Omkar Singh, Rajesh Singh, Rakesh Goel, Dayanand DOS: 11/2011, DOC: 10/2014	Dr S N Rai advised to intrepret water quality data on the basis of geological formations in the basin. Dr. Sharma noted the suggestions. Dr V V Rao suggested to prepare spatial distribution for different parameters. Dr Sharma replied that these plots are being prepared and will be included in the report.
2.	Development of low cost media for fluoride removal from drinking water of fluoride affected areas. Team: Rajesh Singh (PI), Omkar Singh, M.K. Sharma, Dayanand DOS: 04/2011, DOC: 03/2013	Dr. S. N. Rai advised to refer de-fluoridation technology developed by NEERI. PI noted the suggestions.
3.	Water Quality Modeling of Hindon River. Team: Omkar Singh (PI), M.K. Sharma, Rajesh Singh, A.R. Senthil Kumar, Beena Prasad, Dayanand DOS: 04/2012, DOC: 03/2015	Dr. N B Narasimha Prasad advised to combine Study S.No. 1 & 3 keeping in view of the same study area for both studies. Chairman infomed that it would be a combined study. Dr. S. N. Rai informed that pollution from drains can be substantially reduced through the use of sand/carbon barrier/filter. PI noted the suggestions.

GROUND WATER HYDROLOGY DIVISION

Dr. N.C. Ghosh, Scientist-F and Head of the division presented an overview of the scientific activities pursued by the division in the last six months, outlining particularly the R & D studies, consultancy project, and other technical activities. Dr. Ghosh informed that out of 7 approved R&D studies for the year 2012-13, two studies were to be completed, however, because of non-availability of soil samples analyzed results the study entitled “Quantification of Impact of Rainwater Harvesting on Groundwater Availability in Aravalli Hills – Part II: Mathematical Modeling” could not be completed. While the remaining five studies, which have time line up to March, 2013 or beyond, will continue.

It was also informed that under the European Union funded collaborative R&D project ‘Saph Pani’, a training workshop on “Riverbank Filtration” was organized in

the month of April, 2012 at New Delhi, and two more training courses, one on "Managed Aquifer Recharge" scheduled during December, 2012 at Chennai under 'Saph Pani' and the other one on "Coastal aquifer management" scheduled for February, 2013 at Gujarat under HP-II(PDS) are in the pipe line to organize during the current financial year. An account of scientific papers submitted/published in various journals/conferences/symposia, lectures delivered in various training courses and ME/M.Tech and summer trainees guided by the scientists during the period had also been indicated,

Thereafter, PIs of the concerned studies presented the detailed progress of each study. The study-wise progress reported and suggestions emerged are given below.

1. Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India [Project Ref. Code : EU-sponsored Project no. 282911].

Dr. N. Ghosh presented an overview of the 'Saph Pani'and the work packages in which NIH are associated. He had also briefed the various activities pursued during the last six months; which included preparation of a MAR review report; organizing training course & participation in the India Water Week-2012 and its exhibition; participation in the biannual review meeting held at Basel, Switzerland; progress of different work packages, etc.

On an enquiry from Dr. Deshpande, NPL with regard to 'Soil Aquifer Treatment (SAT)" and from Dr. NBN Prasad, CWRDM, Kerala on "Wetland Management Technique", Dr. Ghosh informed that SAT as a component of 'MAR' is already taken into consideration in some of the pilot case studies, and the 'Wetland Management' component is being studied by IIT Bombay along with other partners.

2. Quantification of Impact of Rainwater Harvesting on Groundwater Availability in Aravalli Hills – Part II: Mathematical Modeling [Project Ref. Code: NIH/GWD/NIH/10-12].

Dr. Anupma Sharma explained the background and objectives of the study, data monitored and field investigations carried-out in Savana macro-watershed located in Jaisamand Lake catchment. Due to delay in analysis of soil samples on account of lab renovation work, she informed that the mathematical modeling work was yet to be completed and therefore the project report would be completed by the end of the current financial year. Dr. G.P. Juyal informed that studies on recharge from ponds in Gujarat had been carried out by CSWCRTI and suggested to consult these reports for additional information. Dr. R.C. Jain opined that in view of large number of harvesting structures constructed in the area, the study should include optimization of locations of anicuts and rainwater harvesting structures in the watershed. On a query from Dr Ravi Chopra about use of landuse information in locating suitable runoff harvesting sites, it was informed that information about the same had already been included in the analysis.

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

Dr. Anupma Sharma presented the groundwater salinity issues in Coastal Saurashtra and the various measures taken by the State Dept. to prevent ingress of saline water through creeks and freshwater reservoir schemes. On a query from Dr. NBN Prasad, the groundwater TDS values monitored using TLC meter were graphically shown and the depth-wise increase in salinity at a specific location was explained. Dr S N Rai queried about the sudden rise in water table in one of the piezometers. It was informed that the same phenomena had been observed in all the nearby piezometers with a consequent decrease in salinity levels. Results of socio-economic survey were also presented.

4. Hydrological Instrumentation and Data Monitoring Planning for Integrated Water Resources Management (IWRM) of the Bina River Pilot Basin [Project Ref. Code: NIH/GWD/NIH/12-13]

Dr. Surjeet Singh presented the progress of the study for developing procedures and guidelines for instrumentation and data monitoring network in the Bina pilot basin. The progress was reported mainly on the data collection, GIS database development, characterization of the study area, existing monitoring network and proposed schemes in the basin. Some of the Working Group members enquired about the GIS and toposheet scale but no recommendations were made.

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

Mr. Sumant Kumar (PI) presented the objectives, statement of the problems, achievements and the future plan of the study. PI informed that there are two options for GW recharge; one is through existing talabs in Raipur city, and other option is to recharge the GW in New Raipur area which is under development. PI was advised to see the connectivity between surface water of existing talabs and GW. Query was raised for recharge site and it was clarified.

6. Flow and Contaminant Transport Modeling of Riverbank Filtration
[Under the framework of 'SAPH PANI' Project Work Package – 1(WP-1) – Bank Filtration in Urban Areas under varying Pollutants Loads and Flood situation] **[Project Ref. Code:** EU-sponsored Project no. 282911].

The progress of this study was presented in two parts; one part by Ms. Shashi Poonam Indwar, Scientist-B and the other part by Ms. Stefanie Fischer, Intern from Germany.

Ms. Indwar presented mainly the objectives, statement of the problem, baseline data collection efforts from time to time for the Haridwar site emphasizing mainly on, measurements of groundwater level and river stages at different locations of the River Ganga, water samples collection for water quality and isotope analysis, and various other data efforts for RBF modeling. She had also presented graphical plots of some of the analyzed data.

Ms. Stefanie Fischer gave a brief presentation on the RBF modelling of the Haridwar site. Starting from the conceptualization of the area under the Visual MODFLOW framework including inputs data preparation and up to presentation of results for some preliminary runs, Ms. Fischer explained a general behaviour of the flow patterns and flow paths of the Haridwar RBF site comprising 22 RBF wells with the river Ganga and the Upper Ganga Canal as its time varying model boundaries at two different sides. She informed that precise calibration of the model and its refinement will be carried out as more data are collected. A number of queries on boundary conditions applied, calibration procedure, etc. raised by the members were replied suitably.

HYDROLOGICAL INVESTIGATION DIVISION

S. No.	Title of Study/Project, Study Team, Date of Start (DOS) and Date of Completion (DOC)	Status and Recommendations/Suggestions
	INTERNAL STUDIES	
1.	Estimation of Snow and Glacier Melt Contribution in Melt Water of Gangotri Glacier at Gaumukh using Isotopic Techniques S. P. Rai (PI), Manohar Arora, C. P. Kumar, Rakesh Kumar, Naresh Kumar, Jamil Ahmad, Vishal Gupta DOS: 04/2010, DOC: 03/2013	Status: On-going Study No specific comments/suggestions
2.	Assessment of Radon Concentration in Waters and Identification of Paleo-Groundwater in Punjab State S. K. Verma (PI), Sudhir Kumar, M. S. Rao, Mohar Singh DOS: 04/2011, DOC: 03/2013	Status: On-going Study No specific comments/suggestions
3.	Hydro-geological Assessment of Ghar Area for Artificial Recharge and Water Management Planning P. K. Garg (PI), M. S. Rao, Sudhir Kumar, C. P. Kumar, Tanveer Ahmad, Rajesh Agarwal, Gopal Krishan DOS: 04/2011, DOC: 03/2013	Status: On-going Study No specific comments/suggestions
4.	Assessment of Sensitivity of Open Water Evaporation to Increase in Temperature for Different Climatic Regions of India	Status: On-going Study

	S. D. Khobragade (PI), C. P. Kumar, Manohar Arora, A. R. Senthil Kumar DOS: 04/2012, DOC: 03/2014	Dr. V. V. Rao commented that limited data have been analyzed for Udaipur region. He suggested that more data should be used.
5.	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab M. S. Rao (PI), C. P. Kumar, Gopal Krishan DOS: 07/2012, DOC: 06/2014	**New Study** No specific comments/suggestions
SPONSORED PROJECTS		
6.	National Program on Isotope Fingerprinting of Waters of India (IWIN) M. S. Rao (PI), Bhishm Kumar, Sudhir Kumar, S. P. Rai, S. K. Verma, P. K. Garg DOS: 07/2007, DOC: 06/2013	Status: On-going Study Dr. R. D. Deshpande suggested to find out the sources of air moisture at Kakinada using the meteorological parameters.
7.	Groundwater Dynamics of Bist-Doab Area, Punjab using Isotopes M. S. Rao (PI), Bhishm Kumar, Sudhir Kumar, S. K. Verma, Pankaj Garg, CGWB Officials DOS: 07/2009, DOC: 12/2013	Status: On-going Study Dr. S. N. Rai, NGRI suggested to find out the possible locations of shallow and deep groundwater interaction.
8.	Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka Sudhir Kumar (PI), J. V. Tyagi, S. P. Rai, Anupma Sharma, B. K. Purandara, C. Rangaraj DOS: 07/2009, DOC: 03/2014	Status: On-going Study No specific comments/suggestions
9.	Impact Assessment of Landuse on the Hydrologic Regime in the selected Micro-watersheds in Lesser Himalayas, Uttarakhand S. P. Rai (PI), J. V. Tyagi, M. P. Singh (FRI), Rajeev Tiwari (IGNA), Vishal Gupta, Jamil Ahmad, V. K. Agarwal DOS: 04/2008, DOC: 03/2013	Status: On-going Study No specific comments/suggestions
10.	Development of Spring Sanctuaries in an Urban and a Rural Watershed in District	Status: On-going Study

	Pauri Garhwal, Uttarakhand S. P. Rai (PI), Sudhir Kumar, S. D. Khobragade, P. K. Garg, S. Tarafdar (GBPIHED), Jamil Ahmad, Vishal Gupta DOS: 04/2010, DOC: 03/2013	No specific comments/suggestions
11.	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India M. S. Rao (PI), C. P. Kumar, S. P. Rai DOS: 09/2012, DOC: 08/2013	**New Study** No specific comments/suggestions
12.	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates S. P. Rai (PI), M. S. Rao, Surjeet Singh, S. K. Verma, C. P. Kumar, Sudhir Kumar, V. K. Agarwal, S. L. Srivastava, Vishal Gupta, Mohar Singh DOS: 06/2012, DOC: 05/2015	**New Study** No specific comments/suggestions
CONSULTANCY PROJECTS		
13.	Hydro-geological Studies of Jhamarkotra Mines, Udaipur, Rajasthan Sudhir Kumar (PI), S. K. Verma, P. K. Garg DOS: 07/2010, DOC: 12/2012	Status: On-going Project
14.	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management S. D. Khobragade (PI), C. P. Kumar, R. D. Singh, S. P. Rai, C. K. Jain, V. K. Agarwal DOS: 07/2011, DOC: 06/2013	Status: On-going Project

SURFACE WATER HYDROLOGY DIVISION

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

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

Mrs Archana Sarkar, PI of the study presented the statement, objectives, study area, approved action plan, methodology, progress, results and deliverables of the study. Mrs Sarkar informed that the study area is the Subansiri River basin, the biggest northern tributary of Brahmaputra River within India which originates in Tibet, contains snow-fed tributaries and glaciers and has a huge hydropower potential for the country. She informed the house that the first and second part of the report consisting snow cover mapping which is an input to the snowmelt runoff model in the second part of the study has been completed. She further informed that the study of the impact of climate change on runoff of Subansiri basin in the third part was going under. She further presented the results of trend analysis of daily rainfall, rainy days, daily temperature (maximum, mean, minimum) and diurnal temperature carried out on annual and seasonal periods using parametric (regression) and non-parametric (Mann-Kendall) techniques. Dr Deshpande enquired about the length of data used for trend analysis. Mrs Sarkar replied that 37 years of daily data of rainfall and 33 years of daily data of temperature has been used for the study. Sh. S.N. Rai, Member of the working group enquired about the threshold of Mann-Kendall method used for tend observation. Mrs Sarkar informed that the Mann-Kendall method was used with a 95% criterion in the present study and the Z-statistics (threshold value) for this is 1.96. Sh Patra, Member of the working group enquired about the most robust and popular method of trend analysis. Mrs Sarkar informed that modified Mann-Kendall technique is one of the robust and most popular technique of trend analysis, which is also evident from published literature on trend analysis work.

2. MONITORING AND MODELLING OF STREAMFLOW FOR THE GANGOTRI GLACIER

The study was presented by Dr. Rakesh Kumar, Head, Surface Water Hydrology Division. Dr. Rakesh Kumar explained the objectives of the study viz. (i) continuous monitoring of meteorological and hydrological data for monthly, and seasonal specific water yield and its variability from the year to year; and (ii) to improve the hydrological model developed by the institute for simulating daily streamflow. It was explained that the hydro meteorological data collected for the winter season of 2011 have been processed and analysed. During the winter season, the minimum temperature was observed as -19.8^{o}C on 10th February 2011 and maximum temperature was 16.1^{o}C on 12th October 2011. The discharge during winter was observed between 3 cumecs to 21 cumecs. The suspended sediment data collected from 2008 to 2011 were analysed and it was found that mean monthly suspended sediment concentrations for May, June, July, August and September during the study period were 1011, 1384, 1916, 1675 and 567 ppm respectively, indicating highest suspended sediment concentration in July, followed by August. For the entire melt season, the mean daily suspended sediment concentration was estimated to be 1320 ppm. Similar trends were also found for the sediment load and about 67% of the total suspended sediment load of the melt period was transported during the months of July and August. Sediment yield for the study basin was computed to be about 2,863 tonnes km^{-2}yr^{-1}. For the entire ablation period, the erosion from the Gangotri Glacier basin is estimated to be about 1.0 mm. There was

a poor relationship between sediment concentrqation and discharge and hysteresis effect was prominent in the melt stream. The average percentages of clay, silt and sand were found to be 3, 67 and 30% respectively, which suggest maximum content of silt followed by sand. The collection of data for summer season started in the month of May 2012 and it continued upto 8th October 2012. The processing and analysis of the data are under progress.

3. Climatic Scenarios Generation for Satluj Basin using Statistical Downscaling Techniques

Dr. Rakesh Kumar, Head, Surface Water Hydrology Division explained that it is an internal study and the objectives of the study are: (i) to downscale the GCM Output of CMIP3 models and (ii) to predict future climatic scenarios for Satluj basin. It was explaied that for studying the impact of climate change the future climatic scenarios are needed. These scenarios will be downscaled for the Satluj basin using statistical downscaling technique. The review of literature and data processing have been completed. The data has been downloaded and the procedure for AO quantitative evaluation has been finalized. The quantitative evaluation has been carried out for the CMIP 3 models and it has been found that nearly 5 models out of 24 models are performing better for the region. The study is under progess.

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

Dr. Avinash Agarwal presented the study and the results in the light of suggestion from previous meeting. Presented study area and methodology and results so obtained in details along with the climatic variability and the impacts on stream and spring flows. Discussion were held on the infiltration and water holding capacity of soils, watershed runoff ratio and its variation, modeling of cumulative spring and recession flow and variability of spring behavior and its broad classification. Chairman discussed the possibility of retreating effect of a change while forming a cumulative series. It was informed that retreating effect is possible only when the affect is of noise type but it will be opposite when process is continuously changing with time. There was no specific comment on the study.

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

The study was presented by Dr. A K Lohani. He explained the importance and objectives of the study. He further presented the progress of the study and results of glacial mapping and GLOF modeling. Dr Lohani informed that the analysis is almost complete and sensitivity analysis and report writing is in progress. Dr. J.S. Rawat asked the type glacial lakes and the potential dangerous glacial lakes. Dr Lohani explained the types of lakes in the Himalayan region. Dr S.N. Rai appreciated the work. Further he enquired about the change in size of the glacial lake in the past few years. Dr Lohani explained the procedure and data used for delineating the change in the glacial lake. Dr. V.V. Rao asked the criteria for identifying the potentially dangerous glacial lake. Dr Lohani explained the criteria. Dr T.B. Joseph asked the distance of catchment outlet from the lake. Dr Lohani explained the study area, position of lake and catchment outlet.

6. HYDROLOGICAL STUDIES FOR UPPER NARMADA BASIN

Mr. Jagadish Prasad Patra, PI of the study presented the progress during first year of the ongoing three year study scheduled to complete by March 2014. Objectives of the study with brief methodology and work progress in past six months were presented. The river cross-section survey of Narmada, rainfall frequency analysis and estimated PMF were presented. Further, the Mike-11 model setup and various difficulties in calibrating the model were discussed. There were no specific comments from the members.

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

Dr. R.P. Pandey, PI of the project informed the house that the Bundelkhand region of the country is currently facing water shortages during summer months and this problem became more severe during drought years i.e. 2004-2008. Accordingly, it has been planned to take up a study in a pilot area in Bundelkhand region with the major objective to quantify water scarcity during droughts and to identify possible options for augmenting water supply and minimizing crop loss due to droughts. The PI further reported that the specific objectives of this project are: (a) assessment of drought frequency, duration and severity in Bubdelkhand; (b) quantification of surface water and groundwater availability; (c) assessment of total water demands for domestic, industries and agriculture; (d) assessment of supplemental irrigation to minimize crop loss due to dryspells and droughts; (e) delineation of zones vulnerable to different degree of drought severity, and (f) to suggest an area specific plan for water management in Paisuni Basin. The PI presented the progress of the study and the work remaining to be done during the current year.

8. SEDIMENTATION STUDIES FOR PONG RESERVOIR, HIMACHAL PRADESH

Dr. A. R. Senthil kumar, PI of the project, presented the objectives, methodology and progress of the study in brief. Dr. V. V. Rao, NRSA, Hyderabad suggested to include the effect of the climate change into the sediment yield model to predict the increase or decrease in the storage capacity of the reservoir. Dr. T B Joseph, BARC, Mumbai suggested computing the reservoir life from analyzing the sediment samples from the reservoir by isotope techniques. PI of the project informed that the above suggestions may be taken into account once the envisaged objectives of the project are fulfilled. The chairman asked the PI whether to have more time for carrying the analysis suggested by the members of the working group. The PI of the project replied that additional time will be requested once the envisaged objectives of the project are fulfilled.

WATER RESOURCES SYSTEMS DIVISION

1. INTEGRATED APPROACH FOR SNOWMELT RUNOFF STUDIES AND EFFECT OF ANTHROPOGENIC ACTIVITIES IN BEAS BASIN

Dr. Sanjay K. Jain presented the objectives and progress of the study. He informed that snowmelt runoff simulation, trend analysis etc. have been carried out

and presented earlier. He informed that work is in progress to achieve two objectives of the study. Dr. Jain informed that the task of climate modeling (future scenarios) has been completed by IISc, Bangalore and a report has been received. He informed that simulation of stream flow with this future scenario value is under progress. He also presented the work of water quality analysis. The work carried out using isotopic investigation were also explained. Dr. Deshpade (PRL) asked about the d excess of the snow and melt water and their variation with the season. Dr. S. P. Rai replied about the query in detailed and mentioned that the d excess of snow and meltwater varies between 20 to 30 permil. Dr. Sharad K. Jain inquired about the variation in snow and glacier melt contribution in different months. Dr. Rai replied that due to variation of air temperatue and other climatic condition the meltwater contribution vary in the river discharge. Dr. V. V. Rao, asked about the maximum contribution of snow melt during the summer months. Dr. Rai replied his query also. Mr. R K Khanna said that the future values of rainfall/temperature are very important for climate change studies. Mr. SCR Sharma said that the snow cover in Rohtang pass side is almost finished by the end of August. Dr. Sanjay Jain replied that the snow cover area now is melted out by the end July not in August, may be because of climate change. Dr. V V Rao said that once this type is completed then future prediction can also be made. Mr. R C Jain said that in future values of base flow is not changed much. Dr. Sanjay Jain informed that so far impact of temperature change has been studied. Once precipitation scenarios are incorporated then all these aspects will be studied in detail. Dr. Sanjay Jain informed that the study will be completed by the end of 2013.

2. ASSESSMENT OF EFFECTS OF SEDIMENTATION ON THE CAPACITY/ LIFE OF BHAKRA RESERVOIR (GOBIND SAGAR) ON RIVER SATLUJ AND PONG RESERVOIR ON RIVER BEAS

Dr. Sanjay K Jain informed that a PDS has been taken up by BBMB. NIH is collaborating with BBMB for this study. Dr. Jain presented the objectives and work elements along with the progress of the study. He informed that work of sedimentation rate in both the reservoirs and sediment discharge relationship is already over. The work on sediment yield modeling using ArcSWAT is under progress. ArcSWAT has been applied for Satluj catchment and results of the study have been finalised. Dr. S N Rai asked what the use of this study is. Dr. Sharad Jain said that regular assessment of sedimentation in reservoir is required for that sediment yield estimation is useful. Dr. Sanjay Jain said that in ArcSWAT model whole basin is divided into sub basins therefore sources of sediment can be identified. Dr. Rai further asked whether any catchment treatment study will also be carried out. Dr. J V Tyagi said that the catchment treatment is not in the scope of the study therefore it is not planned. Dr. Jain informed that the study will be completed by the end of June, 2013.

3. Trend and Variability Analysis in Rainfall and Temperature in Himalayan Region

The study was presented by Sh. L. N. Thakural. The objectives of the study are to create the database (Rainfall, Temperature) for the Himalayan region and carry out statistical analysis, trend and climatic variability changes in climatic variables namely temperature and rainfall in Himalayan region, India. The parametric and non-parametric approaches will be used to determine the trends in the time series data of these meteorological variables. During the presentations collection

and availability status of data of temperature and Rainfall time series data for various ground stations for N.E, Central & Western Himalayan region from various sources was presented. For the available raw data of rainfall and temperature which have been processed, the preliminary analysis done for the North-East region was also presented. Dr. R.P Deshpande inquired which part of Himalayan region is more stable as it affects the Indus, Ganges and Brahmaputra basin for which Sh. L. N. Thakural replied that as the analysis for all the Himalayan region is done then can only clear trend will be available. Dr. NBN Prasad inquired about the sources of the data collected for the study.

4. ANALYSIS OF WATER MANAGEMENT SCENARIO IN TAPI RIVER BASIN USING MIKE BASIN

The study was presented by Dr. Rama Mehta. She presented the analysis for Hatnur and Girna reservoirs using Mike Basin. Dr. V.V. Rao, NRSC, Hyderabad suggested that the ground water data for sub basins can also be included for better management. The PI replied that the availability and collection of data from different concerned agencies is very difficult as it is not readily available and this study has to be completed by March 2013. But in future, it can be considered separately.

5. MATHEMATICAL REPRESENTATION OF ELEVATION-AREA-CAPACITY CURVES FOR INDIAN RESERVOIRS

Dr. M. K. Goel (MKG) presented the progress of the study. He informed that the methodology to be adopted for the study has been programmed in MS-Excel and data of 19 reservoirs has been entered. He showed a few slides of data analysis for a few reservoirs. He explained that based on the analysis and data availability of a few reservoirs, it is now envisaged to develop the mathematical relationships within the operation range of a reservoir (between MDDL and FRL).

In response to a query from Prof. K. C. Patra regarding the sedimentation pattern in a reservoir from original and revised curves, MKG informed that the data as supplied by various State Govt. Departments have been used. Prof. Patra informed that appreciable sedimentation has occurred in Hirakud reservoir and its analysis may be included in the study. MKG agreed to the suggestion as the EAC curve of the reservoir is available. Mr. Kishore Kumar suggested that data of 78 major reservoirs in the country is being continuously monitored by CWC and their analysis may be included in the study. MKG agreed to the suggestion as the data is being constantly received at NIH. In response to a query from Dr. V. V. Rao regarding the characterization of a basin for sediment yield, MKG informed that such an inference would not be possible from the present study as all the reservoirs pertaining to a particular type (Type I – IV) would be clubbed for developing a representative mathematical relationship. The Chairman (Dr. S. K. Jain) suggested that such attempts have been tried in the past but acceptable relations could not be established.

6. WEB GIS BASED SNOW COVER INFORMATION SYSTEM FOR HIMALAYAS

The study was presented by Shri D. S. Rathore. The objective of the study is to publish snow cover information on web/ intranet using GIS server for Himalaya. Snow cover thematic maps (2009), GLOBE/ SRTM (250 m) DEM and for part of the area AWiFS data (2009) were downloaded. Temperature data and Aphrodite data were available at NIH. Snow cover maps were mosaiced and processed for removal of clouds, converted to polygon map. Snow cover map were generated from AWiFS data using NDSI technique. Aphrodite rainfall data were processed to created class intervals, polygons and contours. DEM were converted to elevations zone polygons and contours were generated. Basins and elevation zones will be extracted from DEM and statistics of snow cover will be processed for these units. Dr S.N. Rai stressed the need for showing geographical coordinates and annotations in all maps in the presentations. Dr V.V. Rao inquired regarding resolution of the data in the Web GIS, value addition, validation of results and informed that snow maps are available from WRIS Web GIS site. Dr Rao also stated that MODIS data are freely available to the researchers. Mr Rathore replied that for value addition overlay operation is performed on the MODIS snow cover data to remove cloud cover. Resolution of data is same as that of source except some generalization. The snow maps may be compared with maps derived from other data sources. Availability data in other Web GIS platform will be explored. Dr J.S. Rawat inquired whether ETM+ and more fine resolution DEM data will be used and which Web GIS software is proposed to be used. Mr Rathore replied that Indian satellite data (AWiFS) are included in the study and attempt will be made to include ETM+ and fine resolution DEM data. Geoserver open source GIS is proposed in the study. Dr Kishor Kumar inquired regarding access over web/ intranet, web services, dynamic data, continuity of the study. Mr Rathore replied that few data are of external origin and data will be put on web depending on the rights, access policy of the data. WMS, WFS and WCS web GIS services will be made available. Further, it is proposed to provide data for selected years. The proposal for continuing the study, if any, will be brought up subsequently.

7. SOFTWARE FOR FREQUENCY ANALYSIS IN HYDROLOGY

Mrs. Deepa presented the project. She informed that the objective is to develop a menu driven, interactive software for frequency analysis of hydrological data using different distributions. She informed that the idea behind the development of this package is to develop a low cost, flexible, easily upgradable software for frequency distribution having many features. She also informed that a menu driven, user-friendly software is being developed in Visual Basic language to carry out frequency analysis. The software will provide an efficient environment and will be easy to use by water managers. Furthermore, the software will be built with a graphical user interface that requires little training for using it. The software will use a multitude of algorithms for data import, validation and analysis. It allows the handling of a multiple site project and the comparison of quantile estimates with or without historical information. This software will help to calculate probability plotting positions, estimate the parameters of the various statistical distributions, evaluate the fit of these distributions, estimate flood quantiles, and compare estimates obtained with and without use of historical information. The software will compute the maximum likelihood estimates of probability distribution parameters for several

statistical distributions used in flood frequency analysis. The demonstration of the present version of the software was also given in the meeting.

Dr Kishore suggested providing the details of the input data file. Mrs.Deepa informed that a sample input as well as output file will be included in the online 'Help" module. DR S K Khanna suggested contacting CWC to avoid the duplication.

8. Event Based Rainfall Runoff Modelling Using Soft Computing Techniques.

Dr. Rama Mehta presented the study and showed the comparison of results obtained using the grid and cluster methods of soft computing on the published data of Bree (1978; 22 storms) with those obtained using two conventional methods [viz., Bree (1978); and Singh (2007)]. Based on the criteria of percent error in peak and time to peak, the soft computing methods outperformed the Bree's (1978) method, but under performed Singh's (2007) method. Dr. S. N. Rai suggested to critically analyze the factors as why the soft computing methods under performs the Singh's (2007) method and possibly improve upon if some of the techniques used by Singh (2007) can be used also in soft computing. Well receiving and accepting the suggestion, Dr. Rama added that the analysis is in progress for published multi-storms of two other catchments and informed that other more suitable criteria for performance evaluation including the visual graphs are also intended.

9. Hydrological Assessment of Ungauged Catchments (Small Catchment)

Dr. P K Bhunya presented the status of the study in brief covering the objectives, methodology, analysis, and results. He further appraised the house regarding duration of this purpose driven study (PDS). Also informed the house about the progress of studies that was presented in last working group, and the works carried from inception of this project till date Dr. Bhunya presented briefly about the expected outcome, results in regards to the objectives and the works that is being left and have to complete by March 2013. Dr. Bhunya also briefed the house regarding the technical results that included regional flow duration curve. He also presented the revised results of heterogeneity tests, and the regional flood frequency model-parameter, regional hydrographs parameters using the earlier method and a new method. Dr. Bhunya further briefed the house about the last training course. The photos taken recently by staffs during the field trip to the basins were displayed and the technical publications that are allied in this project area were also discussed. There were no questions from the members.

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)

S. N.	Title of Project/Study, Study Team, Start/Completion Dates	Status and Recommendations/Suggestions
1.	Recession Flow Analysis for Evaluation of Spring Flow in Indian Catchments Team: Ravindra V. Kale (PI), V. C. Goyal DOS: Apr 2011; DOC: March 2013	Status: Ongoing study No specific comments.
2.	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs (**Joint study)** **NIH HQs:** V C Goyal (Leader) Ravindra V. Kale New Scientist **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu, RC-Kakinada, RC-Sagar, CFMS-Guwahati, CFMS-Patna DOS: Apr 2012; DOC: Mar 2015	Status: Ongoing study No specific comments.

The Working Group noted the progress of the studies undertaken. The Chairman thanked the members for their valuable contributions during deliberations in the Working Group meeting.

The meeting ended with vote of thanks to the Chair.

ANNEXURE-I

List of Working Group Members attended the 37th WG meeting

1	Dr.S.K. Jain, Director-Incharge, NIH	Chairman
2	Dr. R C Jain, Regional Director, CGWB, Dehradun	Member
3	Sh. Sanjeev K. Sharma, Director, GSI, New Delhi	Member
4	Dr. Kishore Kumar, NIC, WRID,New Delhi	Member
5	Dr. G P Juyal, CSWCRTI, Dehradun	Member
6	Dr. S.C.R. Vishwakarma, GBPIHED, Almora	Member
7	Sh. T.B. Joseph, BARC, Mumbai	Member
8	Dr. R.D. Deshpande, PRL, Ahmedabad	Member
9	Dr. V V Rao, NRSC, Hyderabad	Member
10	Dr. S. N. Rai, NGRI, Hyderabad	Member
11	Dr. N.B. Narasimha Prasad, CWDRM, Kozhikode	Member
12	Prof. J S Rawat, Kumaun University, Almora	Member
13	Prof. K.C. Patra, NIT Rourkela	Member
14	Er. R K Khanna, Chief Engineer (Retd.), CWC	Member
15	Dr. N.C. Ghosh, Sc. F & Head GWH Division, NIH	Member
16	Dr. Rakesh Kumar, Sc. F & Head SWH Division, NIH	Member
17	Dr. C.K. Jain, Sc. F & Head EH Division, NIH	Member
18	Sh. C.P. Kumar, Sc. F & Head HI Division, NIH	Member
19	Dr. V. C. Goyal, Sc. F & Head RMO Division, NIH	Member-Secretary

Scientists from National Institute of Hydrology, Roorkee

1. Dr. S. K. Singh, Sc. F
2. Dr. Sanjay Jain, Sc.F
3. Dr. Avinash Agarwal, Sc.F
4. Dr. J.V. Tyagi, Sc.F
5. Dr. Sudhir Kumar, Sc.F
6. Dr. M.K. Goel, Sc.F
7. Smt. D.Chalosgaonkar, Sc.F
8. Dr. D.S. Rathore, Sc.E2
9. Dr. A.K. Lohani, Sc.E2
10. Dr. R.P. Pandey, Sc.E2
11. Er. Omkar Singh, Sc.E2
12. Dr. Suhas Khobragade, Sc.E1
13. Dr. P.K. Bhunya, Sc.E1
14. Dr. S.P. Rai, Sc.E1
15. Dr.A R Senthil Kumar, Sc.E1
16. Dr. Anupama Sharma, Sc.E1
17. Dr. M.S. Rao, Sc.E1
18. Dr. Sanjay Kumar, Sc.E1
19. Dr. Surjeet Singh, Sc.E1
20. Dr. R.D. Mehta, Sc.C
21. Sh. S.K. Verma, Sc.C
22. Smt. Archana Sarkar, Sc.C
23. Sh. A.K. Dwivedi, Sc.C
24. Dr. M.K. Sharma, Sc.C
25. Sh. P.K. Garg, Sc.B
26. Sh.Rajan Vatsa, Sc.B
27. Dr. Ravindra Vitthal Kale, Sc.B
28. Sh. J.P. Patra, Sc.B
29. Sh. Sumant Kumar, Sc.B
30. Dr. Rajesh Singh, Sc.B
31. Sh. L.N. Thakural, Sc.B
32. Mrs. Shashi Poonam, Sc.B

ANNEXURE – B

Division-wise Work Programme

ENVIRONMENTAL HYDROLOGY DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2012-13

S.No.	Study	Study Team	Duration
Internal Studies			
1	Assessment of Water Quality in Hindon River Basin	M. K. Sharma (PI) Omkar Singh Rakesh Goel Dayanand	3 Years (11/11-10/14) Status: In progress
2.	Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas	Rajesh Singh (PI) Dayanand	2 Years (04/11-03/13) Status: In progress, Extension requested for 6 months
Consultancy Project			
1.	Pilot Study on Ground Water Pollution in Hindon - Kali - Krishini River Catchment in Western Uttar Pradesh	C. K. Jain (PI) M. K. Sharma Rajesh Singh Babita Sharma Beena Prasad Rakesh Goyal Daya Nand	6 Months 12/12-05/13 Status: In progress

PROPOSED WORK PROGRAMME FOR THE YEAR 2013-14

S.No.	Study	Study Team	Duration
Internal Studies (Continuing)			
1.	Assessment of Water Quality in Hindon River Basin	M. K. Sharma (PI) Omkar Singh Rakesh Goel Dayanand	3 Years (11/11-10/14) Status: In progress
2.	Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas	Rajesh Singh (PI) Dayanand	2 Years (04/11-03/13) Status: Not completed, Extension requested for 6 months
Proposed New Studies			
3.	Applications of Nanotechnology in Water Sector	C. K. Jain (PI) Dinesh Mohan (JNU) Babita Sharma	1 Year (04/13-03/14) New Study
4.	Ground Water Quality Mapping and Surveillance for Safe Water Supply in District Hardwar and Dehradun, Uttarakhand	C. K. Jain (PI) P. K. Garg (IITR) Rama Mehta S. K. Sharma Yatveer Singh Babita Sharma	1 Year (04/13-03/14) New Study
5.	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) C. K. Jain	1 Year (04/13-03/14) New Study
Consultancy Project			
1.	Pilot Study on Ground Water Pollution in Hindon - Kali - Krishini River Catchment in Western Uttar Pradesh	C. K. Jain (PI) M. K. Sharma Rajesh Singh Babita Sharma Beena Prasad Rakesh Goyal Daya Nand	6 Months 12/12-05/13 Status: In progress

Outreach Activities for the Year 2013-14

1. Mass Awareness Programme:

S.No.	Activity	Venue	Tentative time
1.	Mass Awareness Programme on 'Water Conservation and Water Quality' (Under Hindi Cell)	Any Village in Uttarakhand	1-day activity in Aug. 2013
2.	Mass Awareness Programme on 'Water Conservation and Water Quality' (As per the directions of MoWR)	Identified Villages in Uttarakhand	To be decided by MoWR

2. Brainstorming Session:

S.No.	Topic of Brainstorming Session	Coordinator	Organization & Place	Period & Tentative Dates
1.	Applications of Nanotechnology in Water Sector	Dr. C. K. Jain Sc. 'F'	NIH, Roorkee	1 Day Feb. 2014

3. Training Course:

S.No.	Title of the Training Course	Period & Tentative Dates	Course Coordinator	Training is proposed as
1.	Water Quality Monitoring and Assessment	5 Days May 2013	Dr. C. K. Jain Sc. 'F'	PDS HP-II
2.	Advanced Soft Computing Techniques in Hydrological Applications	5 Days June 2013	Dr. Rama Mehta Sc. 'D'	Institute Activity
3.	Environmental Hydrology with Special Reference to Surface and Ground Water Quality	5 Days July 2013	Dr. C. K. Jain Sc. 'F'	Institute Activity
4.	Hands on Advanced Instruments of Water Quality Testing	5 Days Nov. 2013	Dr. C. K. Jain Sc. 'F'	Institute Activity

4. Capacity Building / Training of Scientists and Staff:

S.No.	Name of employee	Topic	Organization & Place	Period
1.	Smt. Babita Sharma, RA	Hands on Advanced Instruments of Water Quality Testing	NIH, Roorkee	5 Days Nov. 2013
2.	Smt. Beena Prasad, RA	- do -	- do -	- do -

Progress of Studies 2012-13
Study – 1

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

2. Study Group:

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

3. Type of Study: Internal

4. Nature of Study: Water Quality and Human Health

5. Date of Start: 1.11.2011

6. Scheduled Date of Completion: 31.10.2014

7. Duration of the Study: 3 years

8. Study Objectives:

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

9. Statement of the Problem:

The River Hindon is subjected to varying degree of pollution caused by numerous untreated and/or partially treated waste inputs of municipal and industrial effluents. The main sources of pollution in River Hindon include municipal and industrial (sugar, pulp and paper, distilleries etc.) wastes from Saharanpur, Muzaffarnagar and Ghaziabad urban areas. The water quality of the River Hindon gets further deteriorated due to confluence of River Kali and River Krishni. The river is highly influenced due to heavy metals, pesticides, which enter the river system, by direct discharges of municipal and industrial effluents and surface runoff. These toxic pollutants will ultimately reach the ground water and will enter in the food chain posing a threat to human health because of their carcinogenic nature. The amount of

dissolved oxygen (DO) in water is one of the most commonly used indicators of a river's health. As DO drops below 4 mg/L, the forms of life that can survive, begin to reduce and it is essential to estimate DO in different reaches of the river.

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

10. Approved Action Plan / Methodology:

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

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

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

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

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

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

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

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

ix) Finally, the estimation of downstream DO deficit in different stretches will be carried out using Streeter-Phelps oxygen sag equation,

$D = (k_d L_0/k_r - k_d)(e^{-kd.t} - e^{-kr.t}) + D_0 e^{-kr.t}$ (Streeter and Phelps, 1925)

Where D = Dissolved oxygen deficit (DO_s-DO), DO_s=Saturated value of dissolved oxgen, DO=Actual dissolved oxygen at a given location in the river, k_d=de-oxygenation rate constant (day^{-1}), L_0=initial BOD of the mixture of streamwater and wastewater (mg/L), K_r=re-aeration constant ($time^{-1}$), t=elapsed time between discharge point and distance x downstream (x/u), u=stream speed.

11. Timeline:

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

12. Objectives and achievement during last six months:

Objectives	Achievements
Field visit and sample collection	i) A field visit in Hindon river basin was carried out during January/February 2013. Surface and ground water samples were collected. Cross section and velocity measurements at various sampling locations in the river were carried out.
Analysis and processing of data	i) Collected samples have been analysed for physico-chemical and bacteriological parameters and are being analysed for toxic metals and pesticides. ii) Collected geological and hydrogeological information of Hindon river basin iii) Interpretation of results on the basis of geological formation iv) Processing of river water quality and x-section data for estimation of DO deficit is under progress.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
i) Dr. S. N. Rai advised to intrepret water quality data on the basis of geological formations in the basin	Ground water quality data was processed using Gibbs's hypothesis for interpretation of the mechanisms controlling ground water chemistry.
ii) Dr. N. B. Narasimha Prasad advised to combine study titled 'Water Quality Modelling of Hindon River' with the study 'Assessment of Groundwater Quality in Hindon River Basin'	Both studies combined under the title "Assessment of Water Quality in Hindon River Basin"

14. Analysis & Results:

i) A field visit in Hindon river basin was carried out in the month of January/February 2013 and collected surface water samples from river Hindon, drains and rivers contributing the river Hindon and groundwater samples in the vicinity of the river Hindon. Collected samples have been analysed for physico-chemical parameters and bacteriological parameters and are being analysed for toxic metals and pesticides.
ii) Bacteriological contamination was observed in few ground samples of the study area.
iii) Ground water quality data of pre-monsoon season were processed using Gibbs's Hypothesis for interpretation of the mechanisms controlling ground water chemistry.
iv) Processing of river water quality and x-section data for estimation of DO deficit is under progress.

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

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: None

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

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

20. Study Benefits / Impacts:

Measurable Indicators	**Achievements**
i) Ground water quality and surface water quality data	In progress
ii) Identification and characterization of point sources	In progress
iii) Estimation of rate of re-aeration, de-oxygenation coefficients and DO deficit in different stretches of the Hindon River	In progress

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:

i) Identification of degraded water quality stretches of the river Hindon using Water Quality Index
ii) Processing of data to examine the suitability for different designated uses.
iii) Estimation DO deficit in different stretches of the Hindon River
iv) Possible remedial measures for improvement of river water quality

Study – 2

1. Title of the Study: Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas

2. Study Group:

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

3. Type of Study: Internal

4. Nature of Study: Technology Development

5. Date of Start: 1.4.2011

6. Scheduled Date of Completion: 31.3.2013

7. Duration of the Study: 2 years

8. Study Objectives:

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

9. Statement of the Problem:

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

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

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

10. Approved Action Plan / Methodology:

i) Synthesis of media from baggase fly ash.
ii) Characterization of media using SEM, TEM, XRD and wet analysis.
iii) Sorption studies.
iv) Column studies for application at field scale.
v) Testing of developed media in actual field condition.

11. Timeline:

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

12. Objectives and achievement during last six months:

Objectives	Achievements
Development of media and characterization	Media synthesized from bagasse fly ash. Characterization completed
Adsorption studies	Adsorption studies are under progress
Kinetic & thermo-dynamic studies	Kinetic & thermo-dynamic studies under progress

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
Dr. S.N. Rai advised to refer de-fluoridation technology developed by NEERI	The technology (Chemo-defluoridation and OciMax Electrolytic Defluoridation System referred.

14. Analysis & Results:

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

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

ii) Fluoride specific zeolite based media synthesized from bagasse fly ash.

iii) Characterization of the synthesized media completed.

iv) Adsorption studies are under progress.

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

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: None

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

19. Data procured or generated during the study: None

20. Study Benefits / Impacts:

Measurable Indicators	**Achievements**
i) Development of new product	In progress
ii) Solution of identified problem	In progress

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

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

23. Shortcoming/Difficulties: No

24. Future Plan: Following study components could not be completed in scheduled time and hence six month extension is required to complete the study.

i) Adsorption, kinetic and thermodynamic studies

ii) Column studies

iii) Field trials to see the applicability of the new product at field scale.

iv) Report preparation.

Study - 3 (New Study)

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

2. Study Group:

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

3. Type of Study: Internal

4. Nature of Study: Technology Overview Document

5. Date of Start: 1.4.2013

6. Scheduled Date of Completion: 31.3.2014

7. Duration of the Study: One Year

8. Study Objectives:

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

9. Statement of the Problem:

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

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

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

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

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

13. Methodology:

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

14. Timeline:

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

15. Deliverables: Technical Report / Research Papers

16. Proposed measurable indicator: Application of new technology in water sector

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

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

19. Major items of equipment needed: No

Study – 4 (New Study)

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

2. Study Group:

Project Investigator Dr. C. K. Jain, Sc. 'F' Dr. P. K. Garg (IITR)
Co-Investigators Dr. Rama Mehta, Sc. 'D' Dr. S. K. Sharma, Sc. 'B' Sri. Yatveer Singh, SRA Smt. Babita Sharma, RA

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of Start: 1.4.2013

6. Scheduled Date of Completion: 31.3.2014

7. Duration of the Study: One Year

8. Study Objectives:

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

9. Statement of the Problem:

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

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

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

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

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

A preliminary field visit to some of the villages under Laksar, Khanpur, Bahadrabad and Roorkee Blocks in District Hardwar has already been made by Shri. Yatveer Singh, SRA along with Shri. B. S. Bhist, APS to Hon'ble Union Minister of Water Resources during 6-7 Nov. 2012 and 25 ground water samples were collected. Another field visit to cover the identified villages in Bhagwanpur and Roorkee Blocks as communicated by Dr. Arijit Dey, OSD to Hon'ble Union Minister of Water Resources, was also made and ground water samples were collected. Water Quality Analysis Reports of the two field visits have already been sent vide email dated 24.12.2012 to Sri. Bhist, APS to Hon'ble Minister and Dr. Dey, OSD to Hon'ble Minister. Based on the two reports, three mass awareness programmes have already been organized at Village Sultanpur, Ibrahimpur and Kasampur in District Hardwar.

13. Methodology:

i) Sampling of ground water in pre- and post-monsoon seasons based on habitations
ii) Analysis of physico-chemical parameters: pH, EC, TDS, Alkalinity, Hardness, Major Cations (Na, K, Ca, Mg), Major Anions (HCO_3, Cl, SO_4, NO_3), Minor Ions (F, PO_4, B etc.)
iii) Analysis of bacteriological parameters: Total & Faecal Coliform

iv) Analysis of metals ions: Fe, Mn, Cu, Ni, Cr, Pb, Cd, Zn, As, Hg.

v) Data processing: Data will be processed as per BIS and WHO standards, ionic relationships will be developed and water types will be identified. Spatial distribution maps will be prepared using GIS to identify degraded water quality zones for quality improvement. Suitability of ground water for irrigation purpose will be studied on the basis of total soluble salts, SAR, RSC and B content. Classification of water will be made using Piper trilinear diagram, Chadha's diagram and U.S. Salinity Laboratory classification.

14. Timeline:

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

* As per the directions of MoWR

15. Deliverables: Technical Reports / Research Papers

16. Proposed measurable indicator: Solution of identified problem through assessment of water quality, providing remedial measures and creating mass awareness about quality of water, health effects and responsibility of society to safeguard water resources

17. Involvement of end users/beneficiaries: Local people

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

19. Major items of equipment needed: Water Quality Laboratory facilities

Study – 5 (New Study)

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

2. Study Group:

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

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of Start: 1.4.2013

6. Scheduled Date of Completion: 31.3.2014

7. Duration of the Study: One Year

8. Study Objectives:

To develop a model for assessment of water quality using soft computing techniques.

9. Statement of the Problem:

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

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

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

Water quality data of 300 ground water samples is available for development of model.

13. Methodology:

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

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

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

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

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

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

Soft Computing Techniques (SCT): New emerging techniques such as soft computing techniques (SCT) will be used to develop the model during this study. Fuzzy logic theory under SCT is a convenient way to map an input to an output space. The key idea about fuzzy logic is that it allows an object to have partial membership in set A and partial membership in set B rather having full membership in one set. A membership number between 0 and 1.0 numerically describes the degree of "belongingness" to a set or category.

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

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

14. Timeline:

S.No.	Major Activities	2013-14			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1.	Literature review and data analysis				
2.	Model development with application of soft computing methods				
3.	Testing, evaluation and comparison with conventional methods				
4.	Analysis of results and report writing				

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

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

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

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

19. **Major items of equipment needed:** NA

GROUND WATER HYDROLOGY DIVISION

Scientific Manpower

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

APPROVED WORK PROGRAMME OF THE DIVISION FOR THE YEAR 2012-13

S. No. & Reference Code	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/NIH /10-12	Quantification of Impact of Rainwater Harvesting on Groundwater Availability in Aravalli Hills – Part II: Mathematical Modeling	Anupma Sharma (PI) C.P. Kumar N.C. Ghosh Sudhir Kumar Rajan Vatsa Sanjay Mittal	2 years (04/10 – 03/12) **Status**: Completed	NIH
2. NIH/GWD/NIH /12-13	Hydrological Instrumentation and Data Monitoring Planning for Integrated Water Resources Management (IWRM) of the Bina River Pilot Basin	Surjeet Singh (PI) N.C. Ghosh T. Thomas R.K. Jaiswal T.R. Nayak	1 year (04/12 – 03/13) **Status:** Completed	NIH
Sponsored & HP-II Projects				
3. NIH/GWD/HP-II/10-12	Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat.	N. C. Ghosh (Coordinator) Anupma Sharma (PI) C P Kumar SE (GWRDC, Gujarat) C.K. Jain Sudhir Kumar D.S. Rathore M.S. Rao Surjeet Singh Rajan Vatsa	3 years (10/09 – 12/13) **Status:** In progress & will continue in year 2013-14	PDS (HP-II)
4. EU-sponsored Project no. 282911	Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India"	Project Director : R. D. Singh Project Coordinator & P.I. : N. C. Ghosh Other Team Members V. C. Goyal C. K. Jain Sudhir Kumar B. Chakravorty A. K. Lohani Anupma Sharma Surjeet Singh Sumant Kumar Shashi Poonam Indwar	36 months (10/ 11-9/14) **Status:** In progress& will continue in year 2013-14	European Union under 7th - Framework Programme
5. NIH/GWD/NIH	Management of Aquifer Recharge (MAR) and	Sumant Kumar (PI) Rajan Vatsa	3 years (04/11 – 03/14)	Saph Pani Project

/11-14	Aquifer Storage Recovery (ASR)	N.C. Ghosh C.P. Kumar Surjeet Singh Sanjay Mittal	**Status:** In progress& will continue in year 2013-14	
6. EU-sponsored Project no. 282911	Flow and Contaminant Transport Modeling of Riverbank Filtration	Shashi Poonam Indwar (PI) N.C. Ghosh Anupma Sharma Rajan Vatsa Stefanie Fischer Research Student (Germany)-for six months, HTWD, Germany **Support:** Uttarakhand Jal Sansthan (UJS), Haridwar & Dehradun	2 ½ years (04/12 – 09/14) **Status:** In progress& will continue in year 2013-14	Saph Pani Project

PROPOSED STUDIES FOR THE YEAR 2013-14

S. No. & Reference Code	Project	Project Team	Duration & Status	Funding Source
7. NIH/GWD/NIH /13-14	Estimation of specific yield and storage coefficient of aquifers	Surjeet Singh (PI) N.C. Ghosh Sumant Kumar	1 year (04/13 – 03/14) **Status**: New Study	NIH
8. NIH/GWD/NIH /13-14	* State-of-the-Art Report on Modeling of Coastal Aquifers Vulnerable to Sea Water Ingress	Anupma Sharma (PI) C.P. Kumar (Co-PI) Rajan Vatsa	1 year (04/13 – 03/14) **Status**: New Study	NIH (Reffered by MoWR)

* This study is emerged as an action suggested by Ministry of Water Resources (MoWR) under its National Water Mission on Climate Change.

Consultancy Projects				
9.	Drainage Area Mapping and Hydrological Studies in and around Gurha (W) Block in Kolayat Tehsil of Bikaner District, Rajasthan	N.C. Ghosh (PI) Surjeet Singh Rajan Vatsa Sumant Kumar S.P. Rai	09 months **Status:** In progress	RSMML, Rajasthan

Proposed Outreach activities during the year 2013-2014

1. **Awareness programme on identified topics relevant in the Division.**
   - NIL
2. **Brainstorming session on a relevant topic (1/2-day activity with line department and researchers as participants)**
   - One; possible topics:
     - Managed Aquifer Recharge for sustainable groundwater development & management.
     - Bank Filtration for sustainable drinking water supply.
     - Drinking water source sustainability.

3. **Training course on identified topics relevant in the Division (3 to 5 day activity) - two courses.**
   - Coastal groundwater modelling and management
   - Groundwater modelling and management
   - Managed aquifer recharge or Artificial Groundwater Recharge
   - Conjunctive use of surface water and groundwater.

4. **Plan (giving topic, organizations and place, period) for capacity building /training of scientists and staff in the division**
   - Remote Sensing and GIS application in Groundwater Data Management
   - Groundwater Modelling (Flow and contaminant transport)
   - Groundwater data measurements, aquifer parameters estimation, and characterization.
   - Climate Change versus groundwater resources.

The progress of approved work programme for the year 2012-13 and details of the new studies for the year 2013-14 are given below:

1. PROJECT REFERENCE CODE: NIH/GWD/NIH/10-12

Title of the study: Quantification of Impact of Rainwater Harvesting on Groundwater Availability in Aravalli Hills – Part II: Mathematical Modeling

Study team:

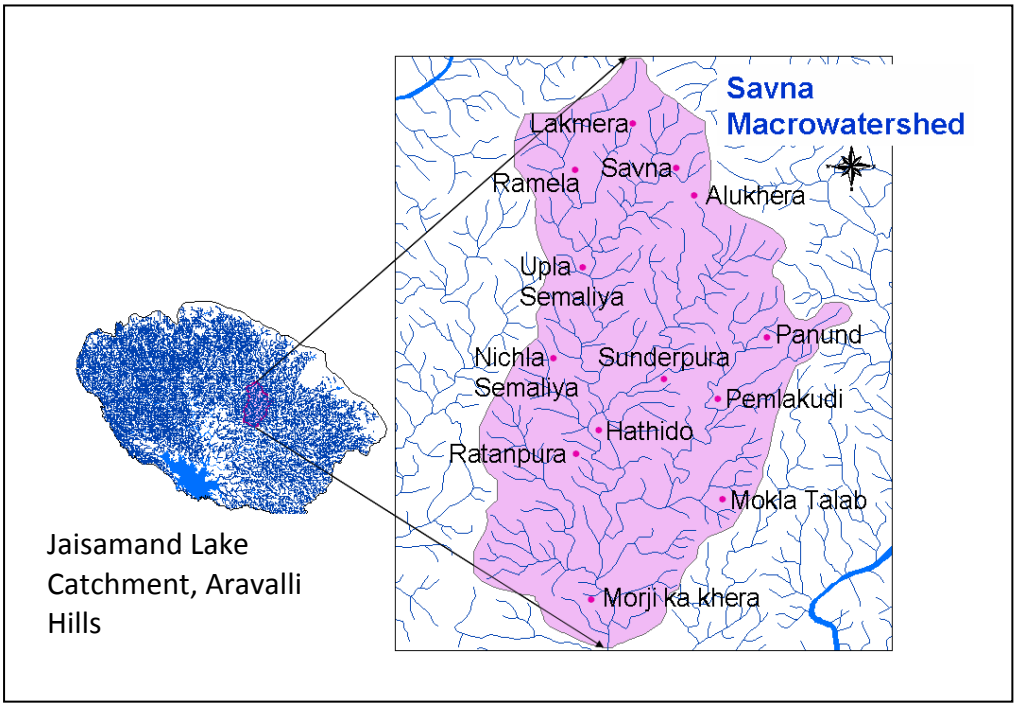
- PI : Dr. Anupma Sharma, NIH
- Co-PI : Mr. C.P. Kumar, NIH
- Co-investigators : NIH - Dr. N.C. Ghosh; Dr. Sudhir Kumar; Mr. Rajan Vatsa; WFI (Udaipur) – Mr O.P. Sharma, Mr Somendra

Type of study (sponsored/consultancy/referred/internal): Internal funding with manpower and logistic support from local non-governmental agencies and beneficiaries of the study.

Date of start: April 1, 2010

Scheduled date of completion: Oct. 2012. Due to renovation of Soil and Water Laboratory, the soil analysis component essential for the study has not been completed till Sept. 2012.

Location map:



Study objectives: To quantify impact of rainwater harvesting schemes on groundwater availability at macrowatershed scale in Aravalli hills using mathematical modeling.

Statement of the problem: To study the enhanced groundwater recharge through recharge structures viz. anicuts in the Savna Macrowatershed of Jaismand Lake Catchment in Aravalli Hills.

Approved action plan: The action plan of the study comprises the following:

1. Field and lab experiments to determine soil moisture retention characteristics and saturated hydraulic conductivity.
2. Estimation of recharge to groundwater, utilizing the database developed in Part I of study.
3. Mathematical modeling to analyze the hydrological impact of rainwater harvesting schemes on groundwater availability.

Objectives vis-à-vis Achievements:

Objectives	Achievements
Data monitoring	Completed
Field and lab experiments	Pump tests; soil analysis; analysis of water quality samples; geophysical survey by WFI, Udaipur, in coordination with NIH.
Mathematical modeling	Computation of water flux through unsaturated zone; Water balance of Savna watershed on GIS; mathematical modeling.

Analysis and Results

1. Updating of database.
2. Geophysical survey and mapping of weathered zone
3. Computation of water flux through unsaturated zone.
4. Water balance of Savna watershed
5. Mathematical modeling
6. Report writing in progress

Adopters of the results of the study and their feedback: Groundwater level monitoring work done by villagers in study area

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

1. Reports – Interim Report
2. Papers

Major items of equipment procured: Nil.

Lab facilities used during the study:

1. Soil and Water Lab, NIH
2. Nuclear Hydrology Lab, NIH

Data procured and/or generated during the study:
Data Generation

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

Study Benefits/Impact (2-column table showing achievements against measurable indicators as mentioned in the approved study document):

Measurable indicators	**Achievements**
Generation of database on GIS for Savna Macrowatershed	Database pertaining to hydrogeology, landuse and soil
Technology transfer	User interactive training

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

- Logistic support from Udaipur based local non-governmental agency Wells for India.
- End-users/beneficiaries: local villagers

Shortcomings/difficulties, if any: -

Future plan: Final report to be submitted.

2. PROJECT REFERENCE CODE: NIH/GWD/NIH/12-13

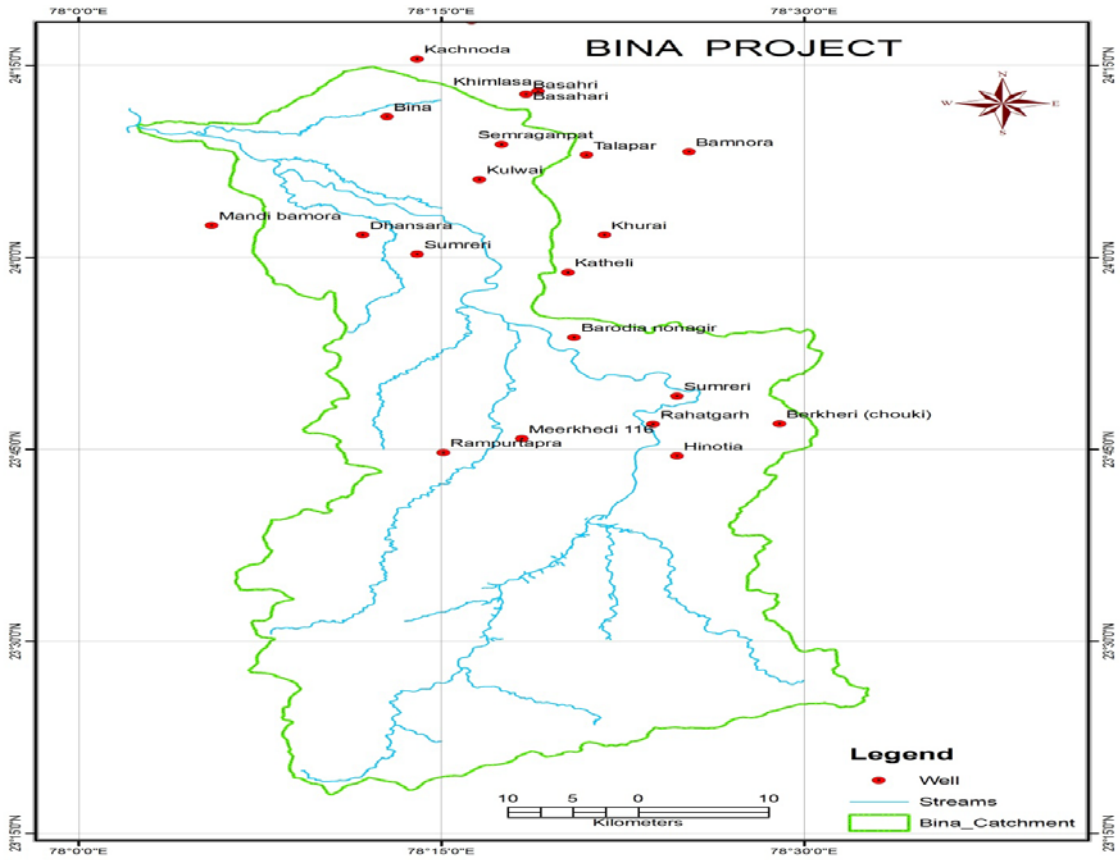
Title of the Study: Hydrological Instrumentation and Data Monitoring Planning for Integrated Water Resources Management (IWRM) of the Bina River Pilot Basin

Study Group:

Dr. Surjeet Singh, Sc-E1 & PI (HQ)
Dr. N.C. Ghosh, Sc-F
Mr. T. Thomas, Sc-C & PI (RC-Sagar)
Mr. R.K. Jaiswal, Sc-C (RC-Sagar)
Mr. T.R. Nayak, Sc-E1 (RC-Sagar)

Funding: Internal
Date of Start: April 01, 2012
Scheduled Date of Completion: March 31, 2013

Location Map: Bina river is a major tributary of River Betwa in Bundelkhand region of Madhya Pradesh, which originates from Begumganj block of Raisen district. Total catchment area of the basin is 2,816.67 sq.km.



Statement of the Problem:

Ganga Plains South Regional Centre, Sagar of NIH has identified Bina as the pilot basin in Madhya Pradesh under its jurisdiction. The Regional Centre, Sagar will work in this pilot basin in an integrated manner. The Centre is also planning for huge instrumentation in the basin for carrying out future studies. In this context, the present study is proposed to develop guidelines for planning of pilot basin for the IWRM. The study will focus on developing guidelines for optimum instrumentation, increase in water resources, supply-demand analysis and groundwater sustainability.

Approved action plan:

- Review of existing and proposed schemes.
- Existing database collection.
- Basic data preparation using GIS.
- Meteorological, hydrological and hydro-geological characterization of the study area.
- Development of procedures and guidelines for optimum instrumentation for IWRM.
- Preparation of optimum instrumentation.
- Preparation of final report.

Timeline and justification for time over runs:

1-3 months: Field visits & data collection.
4-6 months: Assessment of existing & proposed instrumentation.
7-9 months: Development of procedures and guidelines.
10-12 months: Refinements and report writing.

Objectives & Achievements:

Objectives	Achievements
• To analyze and schematize of the existing and proposed schemes of the water usages pattern in8 the basin under the GIS framework.	— Collection of data and basin information. — Review of existing and proposed schemes. — Preparation of various GIS layers. — Characterization of the study area.
• To identify and plan the meteorological/hydrological/hydro-geological data monitoring networks, and devising instrumentation requirement for developing guidelines for the IWRM.	— Development of procedures and guidelines completed. — Refinement and requirement of instrumentation under progress. — Report writing under progress.

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

Analysis and Results:

1. GIS database development.
2. Characterization of the study area.
3. Characterization of the study area.
4. Development of procedures and guidelines.
5. Assessment of instrumentation requirement under progress.

List of deliverables:

1. Report/Manual.

Major items of equipment procured: 01 no. Hand Held GPS.

Lab facility used under the study:

Numerical Groundwater Modeling Unit (NGMU) of NIH is used for GIS related work.

Data procured and generated:

1. Existing monitoring stations, viz. rain gauge stations, river gauging stations, wells, etc.
2. Existing water resources schemes, viz. dams, reservoirs, canals, etc.
3. GIS Layers, viz. basin and command boundary, drainage network, well network, DEM, land use, existing schemes, proposed schemes, etc.
4. Data: toposheets, geological maps, soil maps, litho logs, theissen polygon map, ground water levels, land use map, etc.

Study Benefits:

The study will be beneficial for planning of hydrological instrumentation and data collection procedure to achieve the objectives of IWRM.

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

- End-users/beneficiaries: The study will provide inputs to NIH, RC Sagar, MP State line departments and Local habitants.

Shortcomings/Difficulties, if any:

Data collection process took lot of time to get the data from various State and Central govt. organizations.

Future Plan:

- The study results will be disseminated through training courses to be organized by the Division/other divisions.

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

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

Study team:

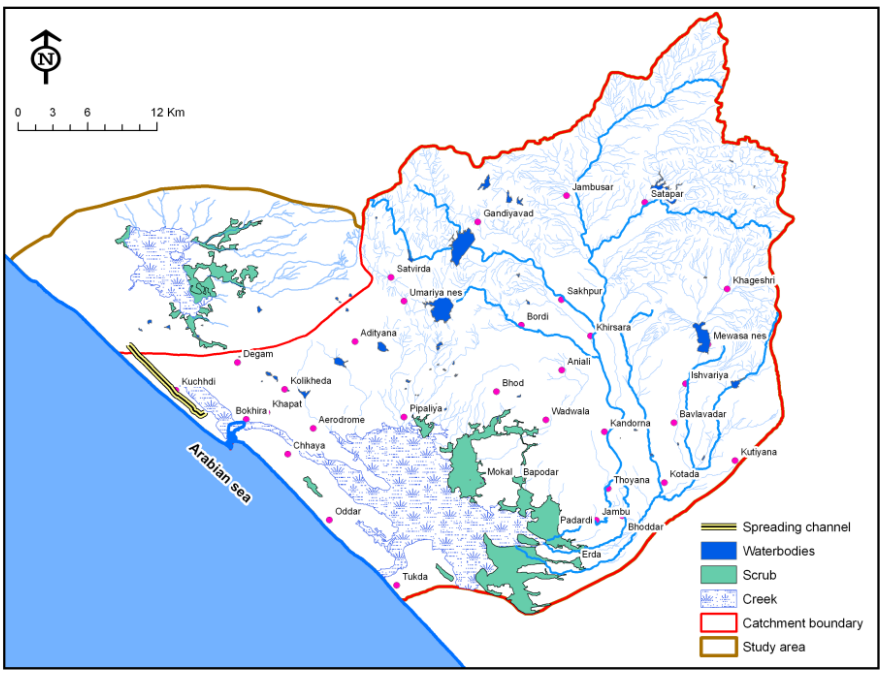
- Study Coordinator: Dr N.C. Ghosh, NIH
- PI : Dr. Anupma Sharma, NIH
- Co-PI : Mr. C.P. Kumar, NIH
  Supt. Engineer, GWRDC, Gandhinagar
- Co-investigators :NIH- Dr. C.K. Jain; Dr. Sudhir Kumar; Mr. D.S. Rathore; Dr. M.S. Rao; Dr. Surjeet Singh; Mr Rajan Vatsa
  GWRDC - Research Officer, Gandhinagar; Geologist, Gandhinagar; Geohydrologist, Rajkot; Geophysicist, Porbandar; Geologist, Porbandar

Type of study (sponsored/consultancy/referred/internal): Sponsored; *Purpose Driven Study* under World Bank funded Hydrology Project Phase-II (HP-II). Study in collaboration with Gujarat Water Resources Development Corporation (GWRDC), Govt. of Gujarat, Gandhinagar

Date of start: Oct. 26, 2009

Scheduled date of completion: Dec. 31, 2013

Location map:



Study Area: Minsar River Basin, Coastal Saurashtra, Gujarat

Study objectives:

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

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

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

Objectives vis-à-vis Achievements:

Objectives	Achievements
Literature review	Completed.
Field visits	Three since Oct. 2012.
Data collection	Collection of data about landuse, river stage and water levels in surface water bodies, groundwater draft, spreading channel, irrigation schemes, relevant maps, meteorological data.

Data monitoring	Water level and water quality data monitoring of wells every two months, including creeks and reservoir schemes near coast.
Field experiments and Laboratory investigations	- Soil samples collected from Kerly Creek, Barda Sagar, river bed: disturbed & undisturbed; rock samples collected - Installation of data loggers and measurement of groundwater level, temperature and salinity using data loggers at three sites - Three permeameter tests near spreading channel, Barda Sagar and Kerly creek and six tests in villages - One observation post installed for stage measurements in tidal creek - Samples for water quality and isotope analysis collected including seawater samples - Measurement of salinity profiles through TLC meter - Geochemical analysis of collected samples
Database preparation	DEM of Minsar basin developed, Fence diagram, Land use, Pump test data, Soil classification, Geochemical data, Water elevations, Water balance.
Data analysis	Analysis of satellite data, pump tests, landuse, water table and water quality data. Data analysis for infiltration and saturated hydraulic conductivity. Water balance computations.

Analysis and Results

1. Topography of Minsar River Basin
2. Analysis of soil characteristics
3. Generation of water table and TDS contours
4. Analysis of lithologs; preparation of fence diagram
5. Hydrological water balance
6. Pump test data analysis
7. Geophysical survey data analysis
8. Geochemical analysis of water samples
9. Socio-economic survey in 21 villages

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 – Interim Report
2. Training Programs
3. Research Papers

Major items of equipment procured:

1. Procurement of pH meter and EC meter (hand-held)

Lab facilities used during the study:

1. Soil and Water Lab, NIH
2. Nuclear Hydrology Lab, NIH

3. Water Quality Lab, NIH

Data procured and/or generated during the study:

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

Study Benefits/Impact:

Measurable indicators	**Achievements**
Generation of database on GIS for Minsar River Basin	Database pertaining to hydrogeology, landuse and soil
Hydrological water balance	Computation of water balance components
Technology transfer	One Training Course on "Coastal Groundwater Monitoring, Assessment and Management" organized at Rajkot during March 4-8, 2013 at Rajkot for Gujarat State Department Officers.

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

Shortcomings/difficulties, if any: -

Future plan:

1. Data monitoring, field surveys and data analysis to continue.
2. Development of numerical model.

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

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

i. **Total Project cost:** Appox. 3.5 million Euros.
ii. **NIH's share** : 2,42,044 Euros
iii. **Duration:** 36 months (October, 2011 – September, 2014).

iv. NIH's Study Team

Project Director: R. D. Singh, Director
Project Co-coordinator & PI: N. C. Ghosh, Scientist-F

Study Team:

V. C. Goyal; C. K. Jain; Sudhir Kumar; B. Chakravorty; A. K. Lohani; Anupma Sharma; Surjeet Singh; Sumant Kumar, Ms. Shashi Indowar; RCs-Jammu, Bhopal, Kakinada, Belgaum, Patna; Sanjay K. Mittal, and Rakesh Goyal.

Project staff
Ms. Stefanie Fischer, Intern from Germany (July, 2012 –March, 2013).
Ms. Saroj Kumari, Project Officer (January, 2013 onwards)
Ms. Manju Rawat (January, 2012 – February, 2013).

v. List of Work Packages

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

vi. NIH's involvement

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

vii. Targeted Areas for R & D works

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

viii. Progress made (Since August, 2012 up to March, 2013)

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

For research, training and demonstration (RTD) purposes, NIH has been entrusted with the Haridwar RBF site for periodic data collection, analysis and modelling. In Haridwar site, 22 large diameter (10 m) bottom entry caisson RBF wells of 7-10 m deep, locally called Infiltration wells(IWs), are operating to abstract bank filtrate water from the river Ganga and the Upper Ganga Canal (UGC) to meet the demand of 50% drinking water supply of the city. Monthly water samples from 29 locations which include 22 IWs, 3 locations each from the river Ganga and the UGC, 3 locations for groundwater samples (Open well) had been collected for previous six months sinnce September, 2012 to determine the concentrations of 20 water quality constituents (16 physico-chemical, 2 bacteriological and 2 heavy metals) and isotopic composition. Water quality and isotopic analysis had been carried out in the water quality and isotope laboratory, respectively of the Institute. Groundwater levels and river stages had also been measured simultaneously. Other auxiliary data for modelling the well fields of the RBF wells such as, meteorological data, borelog data, and aquifer properties had also been collected from different organizations, and sources. The Ganga river stage-discharge data for 11 years (2002-2012) had also been collected. The results of the water quality and isotope analysis are being used for further analysis in conjunction with the RBF processes. The various other data collected from the field investigations are being used for modelling using MODFLOW coupled with MT3D.

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

- From Bihar, a total of 18 sites along river stretches of (i) Ganga in Patna and Danapur, (ii) Gandak in Hajipur (iii) Sone in Funha-Koilwar and Dehri, (iv) Falgu in Gaya and (v) Niranjana in Bodh Gaya, ere obtained through RC-Patna. Water quality analysis of few sites had also been carried out.
- From: RC-Jammu has identified 25 infiltration wells along right and left bank of the Tawi River in Jammu province operating for about 20-22 hours/day for supply of drinking water. These wells are located beyond 100 m.
  Samples collected to determine water quality of source and supplied water are being analyzed at the NIH-Water Quality Laboratory Roorkee.
- From Madhya Pradesh: RC-Bhopal had identified few sites in Sagar, and 2 sites downstream of Karwa Dam supplying drinking water to Bhopal city.. Only Chlorination as post treatment is applied before supply of water. Water quality analysis of sites in Sagar is in progress.
- From Andhra Pradesh : 7 sites along Gostani, Sarada, Varaha River in Vishakhapatnam district and coastal Godavari river.had been identified by RC-Kakinada.

- From Karnataka: Few sites in Belgaum, along Kali River in Uttara Kannada had been identified by RC-Belgaum. Water Quality analysis of identified sites in Belgaum is in progress.

The NIH's inputs for WP1 deliverables due for Month12 (i.e., by September, 2012) on the following had been provided to the package leader, i.e., HTWD who had submitted the compiled information and data to EC for review.

- **Compilation of all information about BF sites in urban areas in India**
- Compilation of relevant site-parameters from the cities of Haridwar,
- Analysis of existing data especially on pathogenic bacteria in river water, bank filtrate and raw water, determination of the methods to be used for field and lab experiments.

For the Month18, i.e., by end of March, 2013, NIH has the following deliverables under this WP:

- Hydrogeological evaluation of bank filtration case study site Haridwar: water quality analysis and modelling of bank filtrate travel-time and flow-path, and
- Flood risk assessment of RBF site in Haridwar.

Analysis, assessment and modelling tasks based on the data collected so far from the Haridwar site have been completed. A detailed report incorporating the hydrogeological aspects, water quality analyzed results and isotopic composition detection, flood risk assessment has been submitted to the package leader.

A 3-Dimensional simulation model using MODFLOW and its sub-modules has been developed incorporating all the RBF wells for the Haridwar site. The model has been calibrated and validated for the steady-state condition. From the steady-state runs of the model travel time and flow path have been ascertain. The transient state modelling for one year duration for different stress and boundary conditions are in progress.

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

For RTD activities on WP-2, NIH has been entrusted with the Raipur Area site along with NGRI, RMC, and KWB-Germany. In the Raipur area, two sites have been identified for MAR study; one is Talibanda Lake area and other one is Talibanda village area.

Based on the data collected in the earlier visits on Meteorology, hydrogeology, groundwater level data, etc. some analysis work has been carried out. NGRI has conducted geophysical study, RMC has to take up drilling work of few bore wells to identify lithology and validation of geophysical data. CGWB-Raipur has been requested to help in the field work.

Based on the work carried out so far by NIH, a report as the M18 deliverable has been submitted to the WP leader, i.e., KWB-Germany.

(c) Work Package 5 : Modelling and System Design

In this work package, NIH has a secondary role, i.e., data being collected from WPs 1,2,3 & 4 will be used for the activities of WP5.

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

(d) Work Package 7 : Training & Dissemination

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

The second biannual review meeting of the 'Saph Pani' project to review the progress of activities was held during 13-14 December, 2012 at Chennai. Anna University organized the meeting. In the meeting, review of progress of each WPs and shortfalls had been discussed along with finalization of work plan for next 6 months.

The second training program on "Managed Aquifer Recharge: Methods, Assessment, Hydrogeological and Water Quality Considerations" had successfully been organized by NIH and Anna University during 11-12 December, 2012 at Chennai.

As part of the dissemination activity, "Saph Pani" matter had been exhibited in different exhibition events where NIH has participated.

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

The third biannual review meeting of the project together with a Practioner exposure tour to Berlin is scheduled to be held during 27, May to 1 June, 2013. Time to time, Tele-conferencing and Skype meeting take place to finalize task, and to review progress of activities.

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

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

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

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

Date of Start : 1st April, 2011

Scheduled Date of Completion : 31st March, 2014

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

Objectives

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

Approved action plan

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

Objectives & Achievements

To identify the potential recharge site for groundwater (GW) augmentation	Recharge sites have been identified
To model & analyze aquifer response due to the recharge from the identified potential recharge site	The modeling task will be taken up after obtaining adequate data and their analysis.
To manage the augmented GW resources for subsequent potential uses	Will be taken up after completion of second objective.

Analysis and Results

To meet the above objectives Meteorological data, Topography, Geological formation, Groundwater Table, Hydraulic properties of aquifer, Soil characteristic, Land uses etc. are required. Meteorological data viz. Rainfall, Temperature, R.H and Evaporation has been analyzed, which will help in estimation of Surface water availability. Topographic data has been analyzed and based on the analysis, a Digital Elevation Map (DEM) is developed and delineation of watersheds and development of drainage networks is completed. GWL data has been analyzed to know the position of Groundwater Table and its direction. Based on the above analysis two sites have been identified one is Teliabanda Lake and other is Teliabanda area (Fig.).

Data Source

Rainfall data - IMD, Pune.
GWL & Geological data - CGWB, Raipur
Meteorological data - Indira Gandhi Viswa vidyalay (IGKV), Raipur
Toposheets - S.O.I, Raipur
City Map - Raipur Municipal Corporation (RMC)

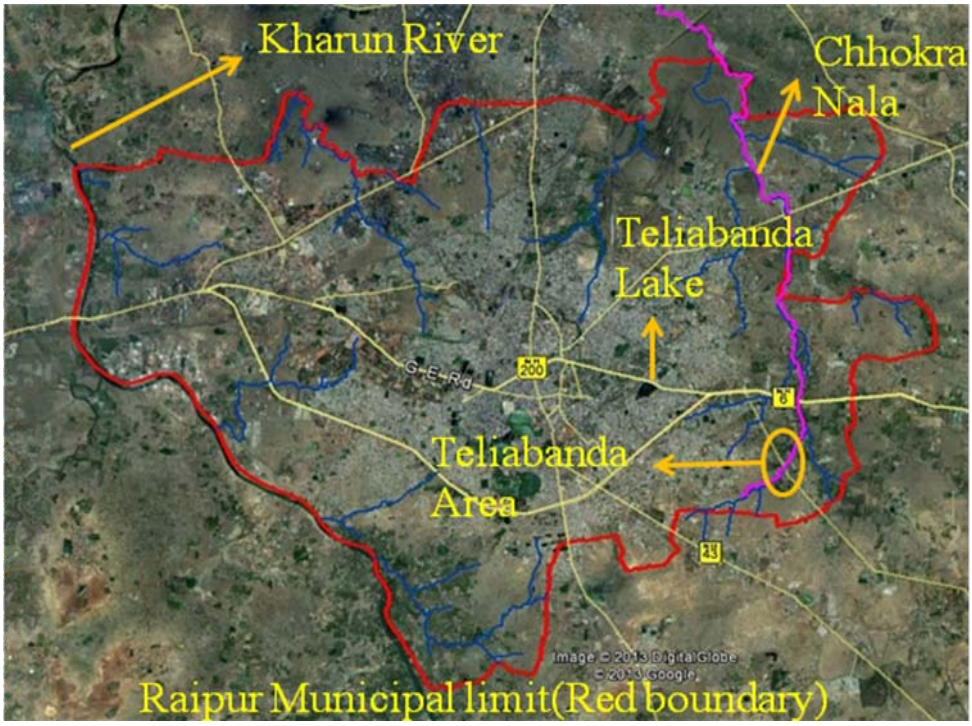


Figure: Location map of identified recharge sites

(Teliabanda Lake & Teliabanda area)

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

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

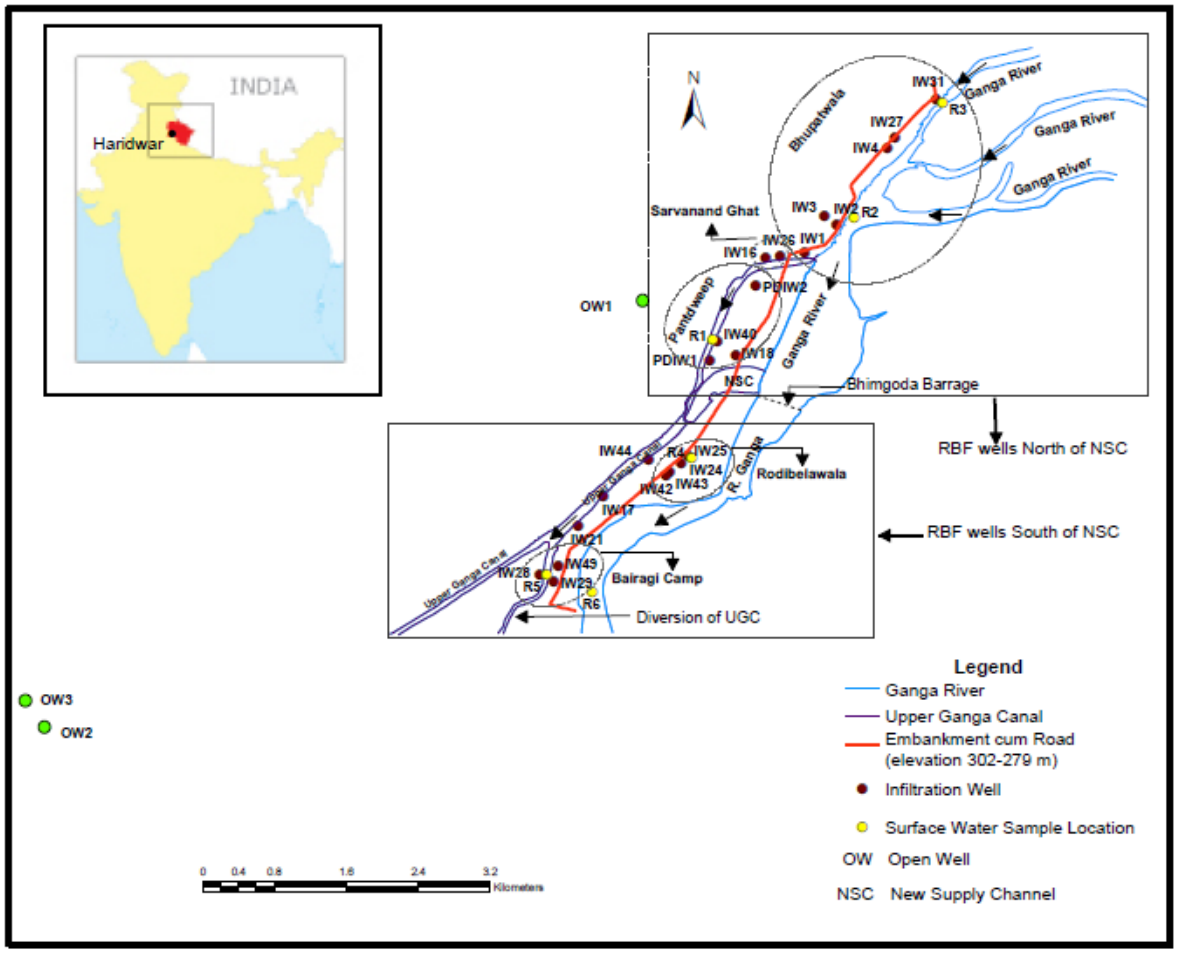
Name of PI: Mrs. Shashi Poonam Indwar, Sc-B
Co-PI: Dr. N.C. Ghosh, Sc-F
Team Members: Dr. Anupma Sharma, Sc-E1
Mr. Rajan Vatsa, Sc-B
Ms. Stefanie Fischer Research Student (Germany)-for six months
HTWD, Germany
Uttarakhand Jal Sansthan (UJS), Haridwar & Dehradun

Nature of study: Technology or technique development

Date of start: 1rst April 2012

Scheduled date of completion: October 2014

Location map



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

Study objectives:

(i) To analyze and model the flow paths and travel times of the existing bank filtration sites along the bank of the Ganga River in Haridwar.
(ii) To model and evaluate removal performance of organic pollutants, coliform bacteria and other pathogens by Bank Filtration.

Approved action plan:

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

Action plan for forthcoming one year (2012-2013)

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

Objectives and Achievements:

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

Analysis and Results:

Description of Area: The bank filtrate of the Haridwar site comprises production of nearly 50% (>43,000 m^3/day) of the total drinking water demand in the city from network of 22 large-diameter (10 m) bottom-entry caisson wells of 7-10 m deep located within area captured by the latitude from 29^o 54' 44.14" N to 30^o0' 10.25" N and longitude from 78^o 8' 33.03" E to 78^o 12' 32.95" E. These 22 RBF wells are

situated along the right bank of the river Ganga at varying distances from it (Figure 1). A number of wells are embraced between the river Ganga and the Upper Ganga Canal (UGC) –a diversion channel that carries regulated flow from the Ganga. Along the river, there is a flood protection embankment constructed by the government to protect entry of flood water from the Ganga to the Haridwar city (Figure). The wells are located on both sides of this embankment. The top surface elevation of this flood protection embankment that ranges between 279 and 302 m above msl is largely above the normal ground surface elevations where these 22 RBF wells are located. The setup of the 22 RBF wells can distinguishably be recognized by two groups: one group is located in the north of new supply canal (NSC) and the other group is in the south of the NSC (Figure 1). The significance of the NSC is that, it is the location where entry of the Ganga water flow to the UGC is regulated by the Bhimgoda barrage headwork. The shortest distance of the 22 wells (Table-1) from the Ganga or the UGC varies between 50 m and 490 m from the centre of the respective water course. These RBF wells in the field are recognized as 'Infiltration Well (IW)' with a specific number assigned by the promoter of the well, i.e., Uttarakhand Jal Santhan (UJS). To maintain conformity with the field, the same nomenclature and the number are also followed in this study.

Normally, 12-13 wells are operated continuously (24 hours) with the remaining wells operating 9-19 hours per day by fixed-speed vertical line shaft pumps connected to the vertical production wells ("tube" wells) through 15 cm dia pipe . The abstracted water is only chlorinated using Sodium hypochlorite (NaClO) at the well particularly, during monsoon season when the river/canal water normally has high turbidity.

Table 1: Distance of the wells from the centre of the river Ganga and the Upper Ganga Canal (IW: Infiltration Well).

Well ID #	Distance from river (m)	Distance from canal (m)
North of New Supply Canal(NSC)		
IW31	102	-
IW27	238	-
IW4	239	-
IW3	333	-
IW2	139	-
IW1	315	102
IW26	-	95
IW16	-	95
PDIW2	693	195
IW40	985	50
PDIW1	982	51
IW18	743	288
South of New Supply Canal(NSC)		
IW25	533	421
IW24	586	491
IW43	683	461
IW42	672	464

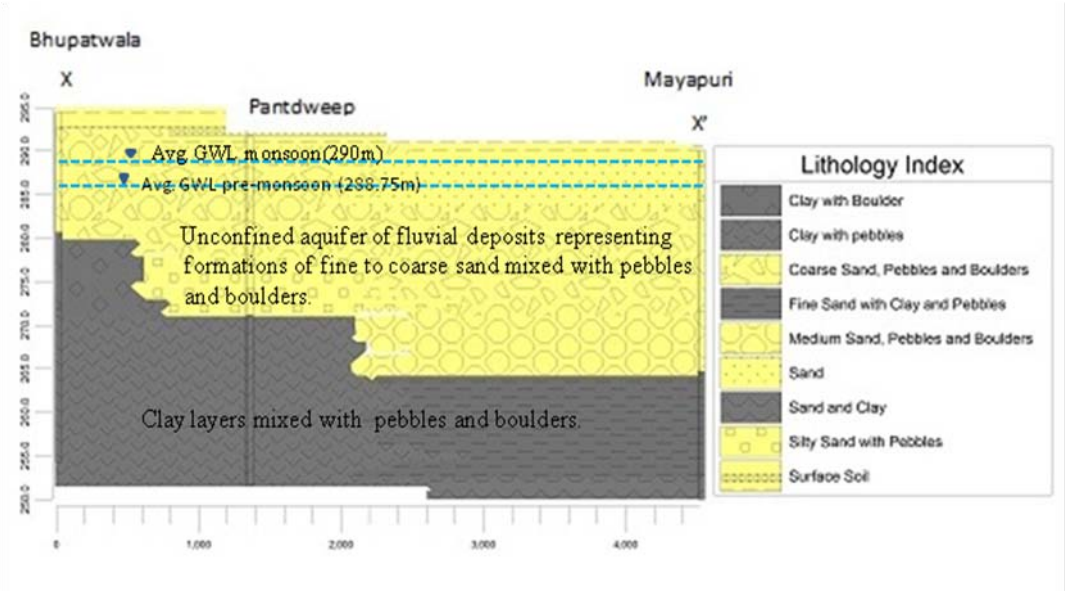
IW44	910	107
IW17	1210	72
IW21	545	110
IW49	368	96
IW29	371	83
IW28	-	61, and 475

The distance of the wells from the centre of the river Ganga and the Upper Ganga Canal is measured using the Arcgis module.The datasource is google imagery dated 26 February 2012. Distance is measured from the well centre to the centre of the river Ganga and Upper Ganga Canal waterline.

Geological and Hydrogeological formation of Haridwar RBF site:

The study area has geological set up comprising Siwalik group having sedimentary formations with conglomeration of sandstone and clay stone sequences. Around Haridwar city area, it has newer alluvium group having Fan alluvium and channel alluvium formation with sequence of brown to grey clay, silt, sand with pebbles and boulders which indicate good recharge zone.

The Hydrogeological setup of the study area indicates that the subsurface formation is overlain by 2m surface soil and below it there is fine to coarse sand mixed with pebbles and boulders showing good hydraulic connectivity between the aquifer and river Ganga as well as Upper Ganga Canal under unconfined condition. The thickness of the unconfined aquifer varies between depth ranges from about 12 m to 36 m below the overburden surface soil. These fluvial deposits are underlain by sequences of large depth of clay layers mixed with either pebbles or boulders, which act as impervious strata with no sign of vertical and horizontal connectivity to the river, canal and the underneath aquifer. The hydrogeological setup of all the 22 RBF wells represents an unconfined aquifer of depth varies between 14 m at the upper reaches and about 38 m at the lower reaches below the ground surface. In terms of elevation, the groundwater table during non-monsoon months occurs at 288.75m above msl. During monsoon months, the groundwater level goes up by an average height of 1.25 m and reaches to the average level of 290m.



Hydrogeological setup of the study area

Periodic collections (bimonthly) of water samples from 22 RBF wells, 3 observation wells, and 2 locations of river (upstream and downstream) and 2 locations of Upper Ganga Canal are made on regular basis for pre monsoon period and post monsoon period. Water quality analysis to determine 21 water quality parameters have been carried out at the Water Quality Lab of NIH. Isotopic analysis for the same samples has also been carried out. Up till now, 10 times sampling of water for water quality analysis, 15 times measurement of flow and groundwater level have been carried out on different dates from May 2012 to February 2013.

Analysis of field data (Conceptualization of the problem, model setup, model data preparation): The Conceptualization of the flow model has been completed.DEM (Digital Elevation Model) for the study area using ASTER data has been generated. Aquifer characterization and hydrogeological evaluation of bank filtration case study site has been completed. Modelling and estimation of bank filtrate travel-time and flow-path is in progress. Water quality analysis for major parameters such as turbidity and pathogens for the samples collected during May, 2012 – February, 2013 has been completed.

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

7. PROJECT REFERENCE CODE: NIH/GWD/NIH/13-14

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

Study Group :Dr. Surjeet Singh, Sc-D & PI
Dr. N.C. Ghosh, Sc-F & Co-PI
Mr. Sumant Kumar, Sc-B

Date of Start : 1st April, 2013

Scheduled Date of Completion: 31st March, 2014

Duration of the Study : One year

Type of Study : Internal

Nature of Study : Technology Adaptation

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

Background

Specific yield (S_y), which is also known as drainable porosity, is the volume of water released from storage by an unconfined aquifer per unit surface area of the aquifer per unit decline of the water table. Specific yield tells how much water is available for use. It is expressed either as a ratio or as a percentage of the volume of the aquifer as follows: $S_y = \frac{V_d}{V_t}$; where V_d is the volume of water that drains from a total volume of V_t.

Storativity or storage coefficient (S) is the volume of water released from storage per unit area of the aquifer per unit decline in hydraulic head in the aquifer. In a confined aquifer (or aquitard), storativity is defined as; $S = S_s b$, where S is storativity, S_s is specific storage and b is aquifer (or aquitard) thickness.

The storativity or storage coefficient of an unconfined aquifer is approximately equal to the specific yield, S_y.

If we want to know the volume of water (V) that will be drained from or added to an aquifer as the head is raised or lowered, the equation for calculation of volume is:

$$V = S\ A\ \Delta h \quad \text{..... (1)}$$

Where S is the storage coefficient, A is the area overlying the aquifer, and Δh is the head raised or lowered.

This equation is primarily followed for estimation of potential groundwater resources in India. Groundwater Estimation Committee (GEC-1984, 1997 and 2004) suggested the following norms for estimation of groundwater recharge:

(i) Groundwater table fluctuation and Specific yield method.
(ii) Rainfall infiltration method.

Between the above two methods, 'Groundwater table fluctuation and Specific yield method' is mostly preferred. The change in groundwater storage volume during pre and post monsoon that appears in the estimation of recharge component is calculated using equation (1). While all other variables of Eq.(1) except specific yield value can explicitly be measured from field observation but the estimation of specific yield in the zone of water table fluctuation, although suggested for computation from pumping tests, is the primary crux of getting reasonable accuracy in the estimate of storage volume. There are guiding values of S_y for different geological formations, but the actual geological formations are rarely found homogeneous and isotropic conditions, mostly heterogeneous and anisotropic. Therefore, selection of appropriate Sy value requires a skilful effort.

There are numerous approaches for estimation of S_y ; these approaches involve laboratory and field based estimation method. Over the years, researchers have carried out a number of studies and suggested different methods for estimation of S_y in the zone of water table fluctuation, and S (storage coefficient). This study is conceived to compile various methods and prepare a state-of-the-art report on the estimation of 'Specific yield and Storage coefficient' in order to help researchers and user organizations for their future endeavour. The objectives of the study are thus envisaged as follows.

Study Objectives:

i. Compilation and critical appraisal on various methods developed and widely used for estimation of Specific yield and Storage coefficient.
ii. Preparation of a state-of-the-art report on estimation of Specific yield and Storage coefficient.

Brief Methodology

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

Milestones and Expected Output / Outcome

'Specific yield' and 'Storage Coefficient' are two important parameters for estimation of groundwater resources. In country like ours, groundwater plays a vital role for uses in all water demanding sectors. Therefore, get to know about the advancement in accurate estimation of these parameters has always been a demanding subject. The proposed technical document will help researchers and groundwater professions to have compiled information and data at one place.

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

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

Study team:

- PI : Anupma Sharma, Sc. D, GWH Div.
- Co-PI : C.P. Kumar, Sc. F & Head HI Div.
  : Rajan Vatsa, Sc.-B

Type of study (sponsored/consultancy/referred/internal): Internal (referred by MoWR)

Date of start: April 2013

Scheduled date of completion: March 2014

Study objectives:

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

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

Other Technical work carried out by the Division

during October – March, 2013

1. The scientists of the Division have 07 publications (accepted/published) in national and international journals/conferences/symposia during the period.

2. The scientists of the Division have delivered **16** of lectures during various training/workshop programmes.

3. The Division has organized 01 training course under HP-II project during 04-08 March, 2013 at Rajkot.

HYDROLOGICAL INVESTIGATION DIVISION

Scientific Manpower

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

NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्ठा मयोभुवः

WORK PROGRAM FOR THE YEAR 2012-2013

S. No.	Study	Team	Duration/ Status
	INTERNAL STUDIES		
1	Estimation of Snow and Glacier Melt Contribution in Melt Water of Gangotri Glacier at Gaumukh using Isotopic Techniques	S. P. Rai (PI), Manohar Arora, C. P. Kumar, Rakesh Kumar, Naresh Kumar, Jamil Ahmad, Vishal Gupta	**3 years** (4/10 – 3/13) **Continuing Study**
2	Assessment of Radon Concentration in Waters and Identification of Paleo-Groundwater in Punjab State	S. K. Verma (PI) Sudhir Kumar M. S. Rao Mohar Singh	**2 years** (04/11-03/13) **Continuing Study**
3	Hydro-geological Assessment of Ghar Area for Artificial Recharge and Water Management Planning	P. K. Garg (PI) M. S. Rao Sudhir Kumar C. P. Kumar Tanveer Ahmad Rajesh Agarwal Gopal Krishan	**2 years** (04/11-03/13) **Continuing Study**
4	Assessment of Sensitivity of Open Water Evaporation to Increase in Temperature for Different Climatic Regions of India	S. D. Khobragade (PI) C. P. Kumar Manohar Arora A. R. Senthil Kumar	**2 years** (04/12-03/14) **Continuing Study**
5	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**2 years** (07/12-06/14)
	SPONSORED PROJECTS		
6	National Program on Isotope Fingerprinting of Waters of India (IWIN)	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. P. Rai S. K. Verma P. K. Garg	**6 years** (07/07–06/13) **Continuing Study**
7	Groundwater Dynamics of Bist-Doab Area, Punjab using Isotopes	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. K. Verma P. K. Garg CGWB Officials	**5 years 3 months** (10/08-12/13) **Continuing Study**
8	Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka	Sudhir Kumar (PI) J. V. Tyagi S. P. Rai Anupma Sharma B. K. Purandara C. Rangaraj	**5 years 6 months** (10/08-03/14) **Continuing study**
9	Impact Assessment of Landuse on the Hydrologic Regime in the selected	S. P. Rai (PI) J. V. Tyagi	**5 years**

S. No.	Study	Team	Duration/ Status
	Micro-watersheds in Lesser Himalayas, Uttarakhand	M. P. Singh, FRI Rajeev Tiwari, IGNA Vishal Gupta Jamil Ahmad V. K. Agarwal	(4/08– 3/13) **Continuing Study**
10	Development of Spring Sanctuaries in an Urban and a Rural Watershed in District Pauri Garhwal, Uttarakhand	S. P. Rai (PI) Sudhir Kumar S. D. Khobragade P. K. Garg S. Tarafdar, GBPIHED Jamil Ahmad Vishal Gupta	**3 years** (04/10-03/13) **Continuing Study**
11	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	M. S. Rao (PI) C. P. Kumar S. P. Rai	**1 year** (09/12-08/13) **New Study**
12	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI), M. S. Rao, Surjeet Singh, S. K. Verma C. P. Kumar, Sudhir Kumar V. K. Agarwal, Rajeev Gupta S. L. Srivastava, Vishal Gupta, Mohar Singh	**3 years** (06/12-05/15) **New Study**
13	Review of Groundwater Resources in the Indo-Gangetic Basin: A Case Study on Resilience of Groundwater in the Punjab to Withdrawal and Environmental Change	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**One year 4 months** (02/13-05/14) **New Study**
14	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI), R. V. Kale M. S. Rao, C. P. Kumar Sudhir Kumar, V. K. Agarwal Vishal Gupta, Mohar Singh	**3 years** (10/12-09/15) **New Study**
CONSULTANCY PROJECTS			
15	Hydro-geological Studies of Jhamarkotra Mines, Udaipur, Rajasthan	Sudhir Kumar (PI) S. K. Verma P. K. Garg	**2.5 years** (07/10-12/12) **Continuing Study**
16	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management	S. D. Khobragade (PI), C. P. Kumar, R. D. Singh, S. P. Rai, C. K. Jain, V. K. Agarwal	**2 years** (07/11-06/13) **Continuing Study**
17	Pre-dredging and Post-dredging Bathymetric Survey of Ramgarh Tal Lake, Gorakhpur, UP	S. D. Khobragade (PI) C. P. Kumar R. D. Singh V. K. Agarwal	For Pre-dredging Survey 6 months (11/12-04/13) **New Study**

PROPOSED WORK PROGRAM FOR THE YEAR 2013-2014

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1	Assessment of Sensitivity of Open Water Evaporation to Increase in Temperature for Different Climatic Regions of India	S. D. Khobragade (PI) C. P. Kumar Manohar Arora A. R. Senthil Kumar	**2 years** (04/12-03/14) **Continuing Study**
2	Water Quality, Hydrogeology and Isotopic Investigations in SW Punjab	M. S. Rao (PI) C. P. Kumar Gopal Krishan	**2 years** (07/12-06/14) **Continuing Study**
3	Water Availability Studies for Sukhna Lake, Chandigarh	S. D. Khobragade (PI) C. P. Kumar Sudhir Kumar A. R. Senthil Kumar P. K. Garg V. K. Agarwal	**2 years** (04/13-03/15) **New Study**
SPONSORED PROJECTS			
4	National Program on Isotope Fingerprinting of Waters of India (IWIN)	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. P. Rai S. K. Verma P. K. Garg	**6 years** (07/07–06/13) **Continuing Study**
5	Groundwater Dynamics of Bist-Doab Area, Punjab using Isotopes	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. K. Verma P. K. Garg CGWB Officials	**5 years 3 months** (10/08-12/13) **Continuing Study**
6	Groundwater Management in Over-Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka	Sudhir Kumar (PI) J. V. Tyagi S. P. Rai Anupma Sharma B. K. Purandara C. Rangaraj	**5 years 6 months** (10/08-03/14) **Continuing study**
7	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	M. S. Rao (PI) C. P. Kumar S. P. Rai	**1 year** (09/12-08/13) **Continuing Study**
8	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI), M. S. Rao, Surjeet Singh, S. K. Verma, C. P. Kumar Sudhir Kumar, V. K. Agarwal, Rajeev Gupta, S. L. Srivastava, Vishal Gupta, Mohar Singh	**3 years** (06/12-05/15) **Continuing Study**
9	Review of Groundwater	M. S. Rao (PI)	**One year 4 months**

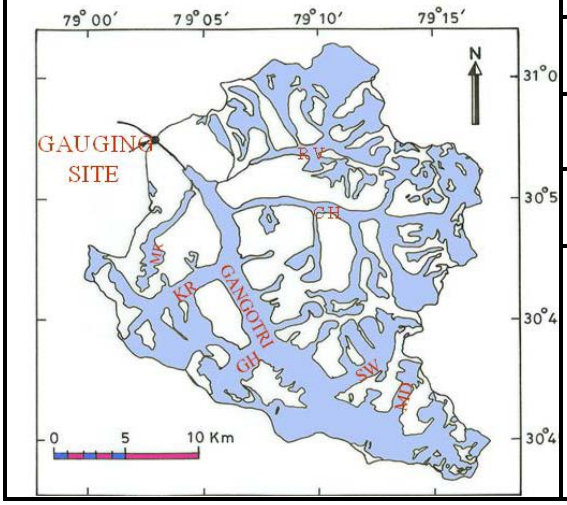
S. No.	Study	Team	Duration/ Status
	Resources in the Indo-Gangetic Basin: A Case Study on Resilience of Groundwater in the Punjab to Withdrawal and Environmental Change	C. P. Kumar Gopal Krishan	(02/13-05/14) **Continuing Study**
10	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar V. K. Agarwal Vishal Gupta Mohar Singh	**3 years** (10/12-09/15) **Continuing Study**
11	Isotope Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI) C. K. Jain S. P. Rai S. D. Khobragade P. K. Garg Two Officers from CGWB	**2 years** (07/13-06/15) **New Study**
CONSULTANCY PROJECTS			
12	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management	S. D. Khobragade (PI) C. P. Kumar R. D. Singh S. P. Rai C. K. Jain V. K. Agarwal	**2 years** (07/11-06/13) **Continuing Study**
13	Pre-dredging and Post-dredging Bathymetric Survey of Ramgarh Tal Lake, Gorakhpur, UP	S. D. Khobragade (PI) C. P. Kumar R. D. Singh V. K. Agarwal	For Pre-dredging Survey 6 months (11/12-04/13) **Continuing Study**

Proposed Outreach Activities of Hydrological Investigations Division for the Year 2013-2014

S. No.	Activitiy	Topic	Duration	Tentative Period	Coordinator
1.	**Awareness Programs**	Groundwater Conservation and Development in Kandi Region, Punjab *(at Govt. Inter College, Bhaddi)*	1 day	16 April, 2013	Dr. M. S. Rao
2.		Conservation of Lakes	1 day	September 2013	Dr. S. D. Khobragade
3.		Groundwater Utilization and Management	1 day	October 2013	Dr. S. P. Rai
4.		Groundwater Availability, Quality and Management in Western Uttar Pradesh	1 day	November 2013	Dr. Sudhir Kumar
1.	**Brainstorming Sessions**	Water Resources in Punjab: Management & Scope for Development *(at PIMT, Amritsar)*	1 day	17 April, 2013	Dr. M. S. Rao
2.		Conservation and Management of Sukhna Lake, Chandigarh *(at Chandigarh)*	1 day	7 May 2013	Dr. S. D. Khobragade
1.	**Training Courses**	Mining Hydrology	5 days	23-27 September, 2013	Dr. Sudhir Kumar & Dr. S. D. Khobragade
2.		Hydrological Investigations for Conservation and Management of Lakes	5 days	November 2013	Dr. S. D. Khobragade
3.		Water Resources Investigations and Management in Coastal Region *(at Kakinada)*	5 days	2-6 Dec. 2013	Dr. M. S. Rao
4.		Application of Isotopes in Hydrology	5 days	January 2014	Dr. S. P. Rai
5.		Advanced Techniques for Hydrological Investigations	3 days	February 2014	Dr. Sudhir Kumar
1.	**Capacity Building**	Training on “Radiological Safety Aspects in Use of Radioisotopes in Research” *(at BARC, Mumbai)*	7 days	December 2013	Dr. S. P. Rai

1. REFERENCE NUMBER: NIH/HID/INT/2010-13

1	**Title of the study**	:	**ESTIMATION OF SNOW AND GLACIER MELT CONTRIBUTION IN MELT WATER OF GANGOTRI GLACIER AT GAUMUKH USING ISOTOPIC TECHNIQUES**
2	**Name of PI, Co-PI, & their affiliations**	:	Dr. S.P. Rai (PI) Dr Manohar Arora Mr. C. P. Kumar Dr. Rakesh Kumar Mr. Naresh Kumar Mr. Jamil Ahmad Mr. Vishal Gupta
3	**Type of study (sponsored/ consultancy/ referred/ internal).**	:	Internal
4	**Date of start, scheduled date of completion**	:	April 2010 to March 2013
5	**Location map (wherever applicable)**		



Glacier Type	Valley
Elevation Range	4000-7000 m
Length	30 km
Width	~0.2 to 2.35 km
Total Area: Glacerised Area	~556 km^2 ~286 km^2

6	**Study objectives**	:	Isotopic Characterization of melt water and individual components (snow-glacier melt, groundwater, rainfall-runoff) Estimation of snow and glacier melt contribution separately and its variability with time

7 **Statement of the problem** : The snow and glacier melt runoff contributes significantly to all north India Himalayan rivers during summer when demand of water increases for hydropower, drinking and irrigation etc. Due to lack of information on hydrological processes of snow/glacier regime and assured availability of melt water, water resources management policies at lower reaches of the glacier fed rivers are often formulated without considering the impact of snow and glacier on river hydrology.

Himalayan glaciers are sensitive indicator of climate changes as the world's other mountain glaciers. Snow and glacier melt isotopic composition can provide information on atmospheric circulation such as responses to climatic fluctuations, changes in the strength of south west summer monsoon, and western disturbances.

Therefore, this study has been taken to study the isotopic composition of snow, rain, ice and melt water which will be useful in separation of various components of stream discharge and in the long term, will be useful to understand the source of moisture and impact of climate change on melting pattern.

8 **Approved action plan** : Please See Annexure 1

9 **Timeline and justification for time over runs** : March 2013

10 **2-column table showing objectives vis-à-vis achievements** :

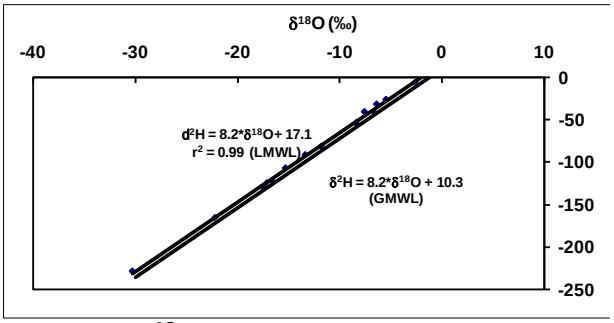
Objectives	Achievements
Isotopic characterization of melt water and individual components (snow-glacier melt, groundwater, rainfall-runoff)	Samples were collected for the ablation period 2011 and sampling for 2012 continued.

Estimation of snow and glacier melt contribution separately and its variability with time	Isotopic characterization of melt water during the ablation periods of 2005 to 2011 under progress.

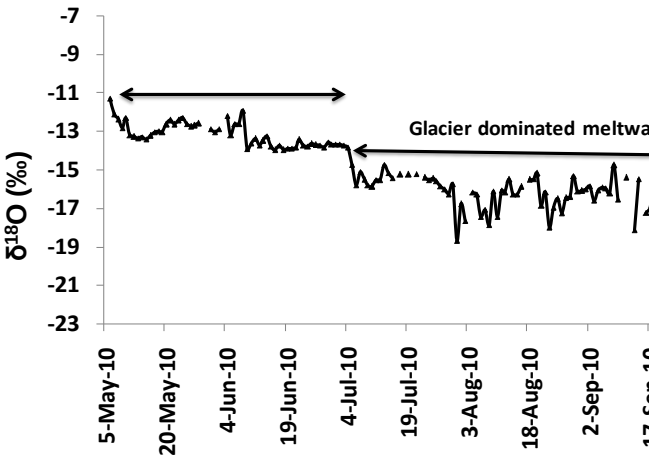
11 **Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken** : NIL

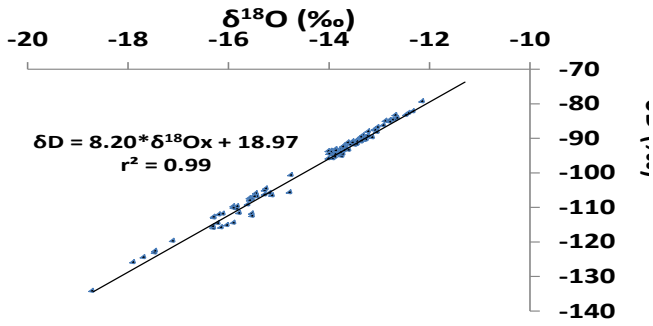
12 **Analysis and Results** :

- The plot of δ^2H versus $\delta^{18}O$ for all precipitation samples collected during the ablation periods. The Local Meteoric Water Line (LMWL) developed as $\delta^2H = 8.2 (\pm 0.10) \times \delta^{18}O + 17.1 (\pm 1.53)$ (n = 15, r2 = 0.99) for a complete ablation period which is showing higher slope and y intercept in comparison to the GMWL.
- It has been observed that the isotopic values of melt initially follow the average $\delta^{18}O$ values of snow ranged between -12‰ to -13.8‰, which shows the enriched value of snow. It may be due to the sublimation process.
- The abrupt change in $\delta^{18}O$ values during the rainfall reflects the contribution from the rainfall-runoff to the stream.
- δ^2H vs $\delta^{18}O$ plot for the meteoric water line developed for melt water of Gangotri Glacier at Gaumukh site and the best fit line is $\delta^2H=8.2*\delta^{18}O + 18.97$ r^2



δ^2H versus $\delta^{18}O$ of precipitation (monthly weighted) during the ablation period 2004 to 2010





δ^2H versus $\delta^{18}O$ of meltwater during the

= 0.99, n = 110 (2010). *ablation period 2010*

- Attempt has been made to separate the snow and glacier contribution at Gaumukh. It appears that contribution of snow is more in comparision to ice.
- The details of the results will be presented in the working group meeting.
-

13 **Adopters of the results of the study and their feedback** : R & D organizations

14 **List of deliverables** : Paper presented in International Conference at Monaco, organized by IAEA. Accepted for the publication in the proceedings.

15 **Major items of equipment procured** : NIL

16 **Lab facilities used during the study** : Isotope and Hydrological Instrumentation Laboratory

17 **Data procured and/or generated during the study** : Isotopic data of the melt water and rainfall at the altitude of 3800 m generated

18 **Study Benefits / Impact** :

Activity	Status
Selection of sampling site	Completed
Sample collection for 2010	Completed
Sample collection for 2011	Completed
Analysis of stable isotopes (δD and $\delta^{18}O$) of collected samples	Completed
Compilation of the results	In progress, report writing in progress

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

20 **Shortcomings/difficulties, if any** : Collection of samples at high altitude

21 **Future plan** : Computation of snow and glacier melt variation with time

Annexure – 1

ACTIVITY SCHEDULE FOR ESTIMATION OF SNOW AND GLACIER MELT CONTRIBUTION IN MELT WATER OF GANGOTRI GLACIER AT GAUMUKH USING ISOTOPIC TECHNIQUES (QUARTER WISE: 2011-12 AND 2012-2013)

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th
Collection of melt water, precipitation, ice and snow samples for isotopic (δD and $\delta^{18}O$) analysis	♦	♦			♦	♦		
Measurement of δD and $\delta^{18}O$ in laboratory			♦	♦		♦	♦	
Development of meteoric water line for melt water			♦	♦			♦	
Establishment of moisture source				♦	♦		♦	
Analysis of discharge data				♦	♦	♦	♦	
Separation of different components of melt water using the isotope model				♦	♦	♦	♦	
First draft report						♦		
Second draft report							♦	
Final report								♦

2. REFERENCE NUMBER: NIH/HID/INT/2011-13/1

Title of the study: **ASSESSMENT OF RADON CONCENTRATION IN WATERS AND IDENTIFICATION OF PALEO-GROUNDWATER IN PUNJAB STATE**

Name of PI, Co-PI, & their affiliations: Mr. S. K. Verma (PI)
Dr. Sudhir Kumar
Dr. M. S. Rao
Mr. Mohar Singh

Type of study: Internal

Date of start, scheduled date of completion:

Start Date: 1st April 2011
Expected end date: 31st March 2013

Location map (wherever applicable):

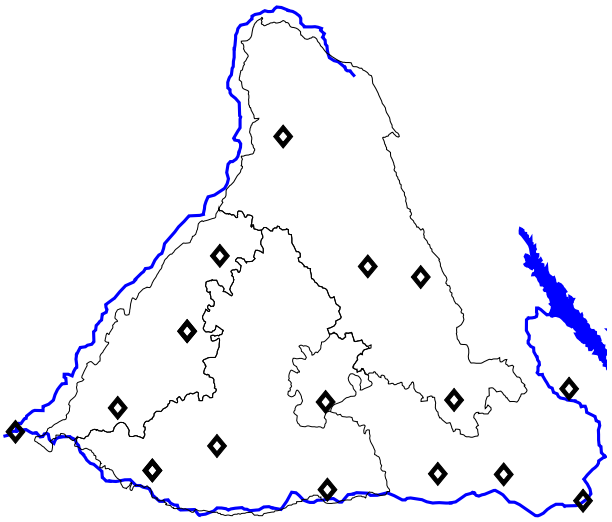


Fig.: Map of Study area

Study objectives:

- To measure radon concentration in waters
- To identify paleo-groundwater in deep aquifers

Statement of the problem:

Radon (^{222}Rn) is a radioactive, colorless, odorless, tasteless noble gas, occurring naturally as the decay product of Uranium. It has a half-life of 3.8 days. Radon gas is considered to be a health hazard due to its radioactivity. It can cause serious diseases like lung cancer if it exceeds certain limit. It has been found that in a country like USA, more than 30,000 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 Punjab state 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 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 Punjab state where tapping of deeper aquifers has started at large scale.

Approved action plan: Please see Annexure 2

Timeline and justification for time over runs: March 2013

2-column table showing objectives vis-à-vis achievements:

Sr. No.	Objective	Achievement
1.	To measure radon concentration in waters	Achieved
2.	To identify paleo-groundwater in deep aquifers	Partially achieved (based on Tritium groundwater dating)

Recommendations/suggestions in previous meetings of Working Group/TAC:

No specific comments were received during the 37th meeting of working group.

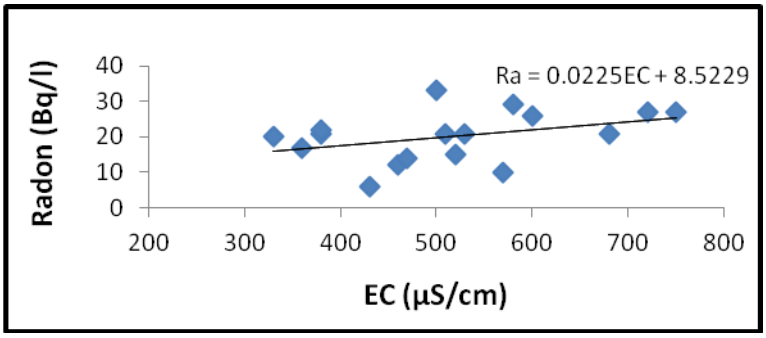
Analysis and Results:

- The analysis of environmental tritium for 14 nos. of groundwater samples collected from district Kapurthala and Jallandhar has been completed in Nuclear Hydrology laboratory. It is found that the tritium unit in water samples varies from 0.5 TU (Kala Sanghian site) to 5.63 TU (Phagwara site) located in district Kapurthala, from 1.74 TU (Jandiala site) to 5.17 TU (Jallandhar site) in district Jallandhar.

- A total of 17 groundwater samples have been analysed for stable isotopes (δD and $\delta^{18}O$) using Isotope ratio mass spectrometer available in Nuclear Hydrology laboratory. Based on results of stable isotope analyses, the variation of $\delta^{18}O$ (‰) with δD (‰) has been studied for the study area and a following local meteoric water line has been developed for the study area.

$$\delta D = 6.2654\ \delta^{18}O - 6.2846$$

- The variation of radon concentration (Bq/litre) with EC (µS/cm) observed at various sites in the study area has been studied. It is found that there is a linear variation in between these two parameters.



Adopters of the results of the study and their feedback:

CGWB (NWR), Chandigarh; Punjab Water Resources Development & Management and Punjab Water Resources & Environment Directorate, Chandigarh.

List of deliverables:

Papers and reports along with the data on radon concentration, isotopic data and paleo-groundwater.

Major items of equipment procured:

Two sets of radon detector with accessories have been procured and installed satisfactorily at Nuclear Hydrology laboratory of the Institute.

Lab facilities used during the study:

Tritium and Carbon dating facilities are proposed to be used at Nuclear Hydrology lab in addition to Radon Detector in laboratory as well as in the field.

Data procured and/or generated during the study:

Generated: Radon concentration and isotopic data for the Bist doab area, Punjab.

Study Benefits/Impact:

- Data base on radon concentration in waters
- Information and data base about availability of paleo-waters in the study area

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

The work is proposed to be carried out with the support of CGWB, Punjab State Water Resources Dept. and Punjab University, Chandigarh.

Shortcomings / difficulties, if any: NA

Future plan: As per activity chart

Annexure - 2

ACTIVITY SCHEDULE FOR ASSESSMENT OF RADON CONCENTRATION IN WATERS AND IDENTIFICATION OF PALEO-GROUNDWATER IN PUNJAB STATE

S. No.	Activity	2011-2012				2012-2013			
		1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1.	Review of literature, collection of hydro-geological data/information for the study area etc.	√	√						
2.	Preparation of index map of study area, selection of locations/sites for experimental works etc.	√	√						
3.	Collection of water samples for radon measurement and tritium analysis, measurement of radon		√	√	√				
4.	Laboratory analysis of water samples for tritium dating			√	√	√			
5.	Collection of water samples for ^{14}C dating					√	√		
6.	Laboratory analysis of water samples for ^{14}C dating						√	√	
7.	Analysis and interpretation of data						√	√	
8.	Preparation of interim report/ Part-1				√				
9.	Writing of report								√

3. REFERENCE NUMBER: NIH/HID/INT/2011-13/2

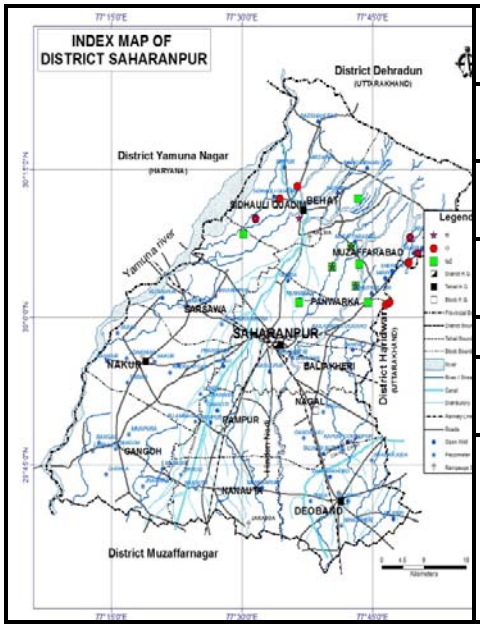
Title of the study : **HYDRO-GEOLOGICAL ASSESSMENT OF GHAR AREA FOR ARTIFICIAL RECHARGE AND WATER MANAGEMENT PLANNING**

Name of PI, Co-PI, & their affiliations: Mr. P. K. Garg (PI)
Dr. M. S. Rao
Dr. Sudhir Kumar
Mr. C. P. Kumar
Mr. Tanveer Ahmad
Mr. Rajesh Agarwal
Dr. Gopal Krishan

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

Date of start, scheduled date of completion: April 2011- March 2013

Location map (wherever applicable)



MUZZAFFARABAD	SADHAULI QUADIM
Study Area - 40621 ha	Study Area - 38767 ha
Govt. Tubewells – 130	Govt. Tube wells – 6
Private Tubewells – 5333	Private Tubewells – 4196
Rainfall – 740 mm	Rainfall – 740 mm
G.W. Utilization - 97.42%	G.W. Utilization - 94.62%
Forested Area – 1910 ha	Forested Area – 1589 ha

Study objectives:

- To identify the groundwater recharge zones and groundwater flow velocity in Ghar area
- To identify sites for water harvesting structures in Ghar area

Statement of the problem:

Two blocks of district Saharanpur (U.P.) which fall in Ghar area namely, Muzaffarabad and Sadhauli Kadim have been taken for this study. The availability of groundwater and surface water is limited in both these blocks which poses problem to meet out the need of drinking water as well as water for irrigation. As per data taken from UP Ground Water Deptt., the groundwater utilization in Muzaffarabad is 97.42% while in Sadhauli Kadim it is 94.62%. Therefore, presently both the blocks fall in dark category and require artificial recharge measures.

Approved action plan: Please see Annexure 3

Timeline and justification for time over runs: NA

-column table showing objectives vis-à-vis achievements:

Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken : NIL

Objectives	Achievements
Review and synthesis of literature and purchase of map	erature survey completed Required data collected and index map prepared.
Data collection and preparation of index maps	Rainfall trend analysis of the Saharanpur district on the basis of 30 years data (1982-2011) in context of agriculture is done.
Analysis of water table data to identify water scarce zones, recharge areas and groundwater safe zones	On the basis of pre and post monsoon groundwater table data, water scarce zones, recharge areas and groundwater safe zones have been identified.
Validation of the isotopic based data results	otopic based results are validated using infiltration sts conducted at 5 locations

Analysis and Results:

There was +0.06 m rise in water table found in Badshahibagh and no variation was recorded at Shakumbhari. At all other sites, the water table was found to decline within the range of -0.09 m to -1.08. On that basis, the entire area has been categorized into safe (<0.1 m/yr), low risk (0.1-0.3 m/yr), medium risk (0.4-0.8 m/yr) and high risk (>0.8 m/yr).

The groundwater fluctuation during the period was in the range of 0.4 to 4.3 m. The lowest recharge (groundwater fluctuation = 0.4 m) was found in Badbala and very high recharge (groundwater fluctuation = 4.3 m) was found in Raipur. On the basis of water table fluctuation, the study area has been categorised into low recharge (<0.5 m), moderate recharge (0.5 – 1.0 m), high recharge (1-2 m) and very high recharge (>2 m).

The sites Sadoli Quadim and Raipur although fall in very high recharge zone category but due to high withdrawals, these sites fall in medium risk category. The sites Badshahibagh and Shakumbari fall in moderate to high recharge zones and due to limited groundwater withdrawals at these sites, the groundwater reserve at these sites is in safe category.

The isotopic analysis of the water samples reveals that the recharge sources can be identified and categorized as - high: source of recharge is canal & isotope value ($\delta\ ^{18}O$) is < -8 ‰; moderate: source of recharge is precipitation & isotope value ($\delta\ ^{18}O$) is -7.4$\pm$0.2‰; average-low: source of recharge is precipitation and isotope value ($\delta\ ^{18}O$) is > -7‰. Depending on the efficiency of surface soils for groundwater recharge low or high; deep well technique or surface recharge procedures can be adopted.

The source of recharging the water table is found to be rainfall and any declining trend in rainfall adversely affects the groundwater availability in the study area. Therefore, the rainfall trend analysis of the Saharanpur for the past 30 years has been done. The variation analysis of rainfall data of Saharanpur reveals a fairly good range of variation indicating the positive trend before 2000 and negative trend from 2000 onwards and that is resulting in depletion of groundwater.

The time series analysis generates valuable information regarding the trend of a series of observations. It helps to measure the deviation from the trend and also provides information pertaining to the nature of trend. The analysis can be used as a tool to forecast the future behaviour of the trend. The method of least square fit of straight line has been used for performing the trend analysis of the behaviour of annual rainfall. On this basis, the future forecast of rainfall amount for a period of 5 years from 2012 to 2016 has been made, which shows a negative trend for the coming years.

For development of water resources in the study area, suitable structures and literature details have been compiled and will be appended in the final report.

Major items of equipment procured : NIL

Lab facilities used during the study: Isotope, Hydrological Instrumentation, and Remote Sensing and GIS Laboratory

Data procured and/or generated during the study: NIL

Study Benefits / Impact:

i) Selection of study site – Site has been selected
ii) Collection of literature – Required literature collected
iii) Collection of water samples – 150 samples collected
iv) Installation of rain gauge - Completed

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

Shortcomings/difficulties, if any: NIL

Future plan: Identification of suitable sites for artificial measures and preparation of final report

Annexure - 3

ACTIVITY SCHEDULE FOR HYDRO-GEOLOGICAL ASSESSMENT OF GHAR AREA FOR ARTIFICIAL RECHARGE AND WATER MANAGEMENT PLANNING

S. No.	Activity	2011-12				2012-13			
		Ist Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1.	Review of literature and purchase of map and data etc.	√	√						
2.	Collection of hydro-geological data/information for the study area		√	√					
3.	Infiltration tests and collection of samples				√	√	√	√	
4.	Preparation of various maps of the study area				√	√	√	√	
5.	Analysis of isotopic and chemical data				√	√	√	√	
6.	Interpretation of data (recharge zones)				√	√	√	√	
7.	Identification of suitable sites/ management measures							√	
8.	Final report							√	√

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

Title of the Study: **ASSESSMENT OF SENSITIVITY OF OPEN WATER EVAPORATION TO INCREASE IN TEMPERATURE FOR DIFFERENT CLIMATIC REGIONS OF INDIA**

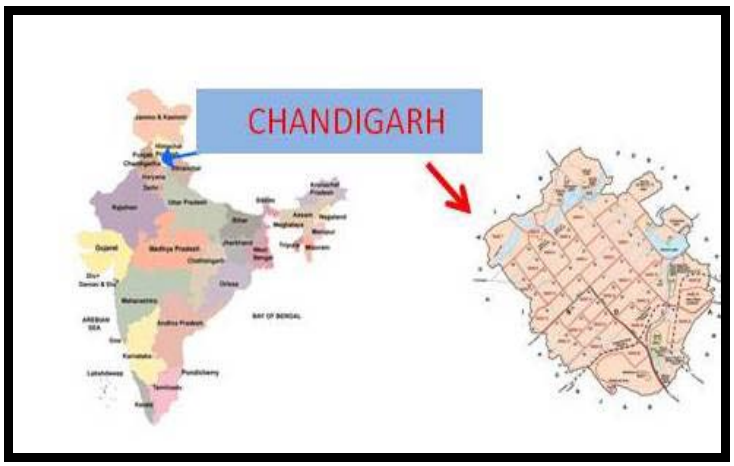
Name of PI, Co-PI, & their affiliations: Dr. S. D. Khobragade (PI)
Mr. C. P. Kumar
Dr. Manohar Arora
Dr. A. R. Senthil Kumar

Type of Study: Internal

Date of start, scheduled date of completion:

Date of Start: April 2012
Date of Completion March 2014

3. Location map (wherever applicable):



Udaipur **Chandigarh**

Fig. 1: Location map of study areas

Study Objectives:

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

Statement of the Problem:

A number of studies have been reported in different parts of the world on the assessment of possible impacts of global temperature rise on water resources and hydrologic cycle. However, only a few studies have emphasized the impact primarily on evaporation. Trend analysis of evaporation data shows different trends in different regions, the world over. Although studies using the GCM's are considered as more realistic for global scales, not all the variables required for calculation of more complex evaporation formulae are available from all climate models. As far as evaporation is concerned, changes in atmosphere variables caused by temperature changes could have an important effect on overall changes in evaporation. Thus, for the purpose of studying impact of global warming on a more specific component like evaporation, specific evaporation model such as Penman model which uses as many input parameters as the factors affecting the process, could be preferable because, as pointed out by IPCC (2001), '*equations that do not consider explicitly all meteorological controls may give very misleading estimates of change*'. Moreover, use of GCM's and RCM's, as well as other sophisticated hydrological models, requires technical expertise that may not always be available locally. For such situations, there is a need for development of a simple methodology to assess the sensitivity of local evaporation to rising temperature using routinely observed meteorological data.

Approved action plan: Please see Annexure 4

Timeline and justification for time over runs:

Time line is as per Annexure 4. No time overruns so far.
2-column table showing objectives vis-à-vis achievements:

Objectives	Achievements
To assess the impact of rising temperature on temperature dependent factors	Analysis completed for Udaipur and Chandigarh
To assess the impact of rising temperature on open water evaporation in different climatic regions of India	Analysis completed for Udaipur and Chandigarh region
To compare the variation in impact on open water evaporation under different climatic settings	Comparison of results carried out for Udaipur and Chandigarh

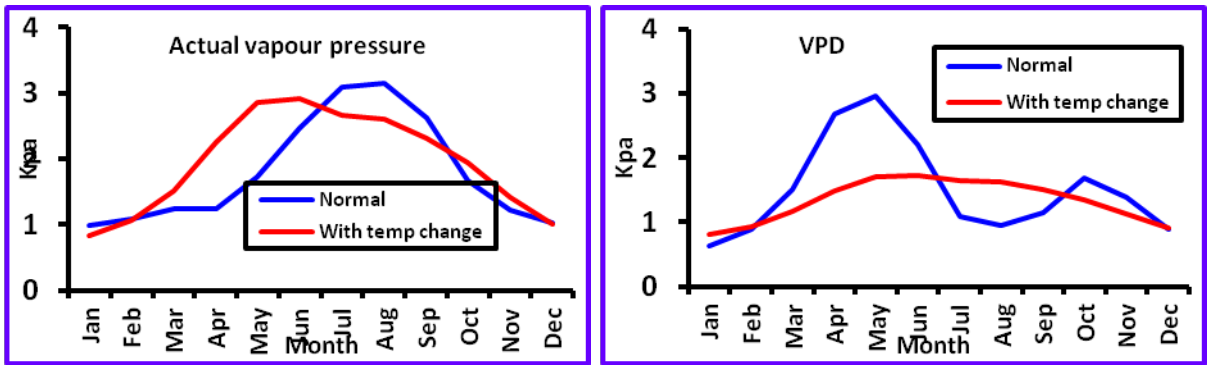
Recommendations/suggestions in previous meetings of Working Group/TAC:

No specific comments were made by either Working Group / TAC.

Analysis and Results

As per objectives of the study, induced variation in temperature dependent parameters due to assumed 1^0C increase in normal mean temperature has been analyzed for Udaipur and Chandigarh. The results for Udaipur were presented during the last meeting. Results for some of the parameters for Chandigarh are shown in Fig. 2. Actual vapour pressure is expected to vary from the present range of 0.98 to 3.15 Kpa to a new range of 0.83 to 2.91 Kpa. However, a very significant shift is expected during the summer months. The change is expected to vary within a range of 2.69% in December to 81.11% in April. Similarly, the saturation vapour pressure is expected to vary by 4.95 to 28.30%. As a result of the change in regime of vapour pressure, both actual and saturated, a significant variation (0.9% - 71%) is expected for vapour pressure deficit. An absolute variation of 0.92% to 33.83% is projected for net long-wave radiation also. This is expected to cause a change in net radiation, by 0.57 to 9.96% during different months.

Based on the expected change in various temperature dependent parameters, impact on evaporation rates has been studied. Results for Chandigarh indicate that 1^0C increase in temperature can cause a significant change in evaporation regime during different months, particularly in summer and monsoon (Fig. 3). While the normal range of evaporation from open water surface at Chandigarh is 3.20 mm (Jan) to 10.98 mm (May) it is expected to shift to a range of 3.44 mm (Dec) to 8.98 mm (May). Thus, evaporation is expected to actually decrease during summer months.



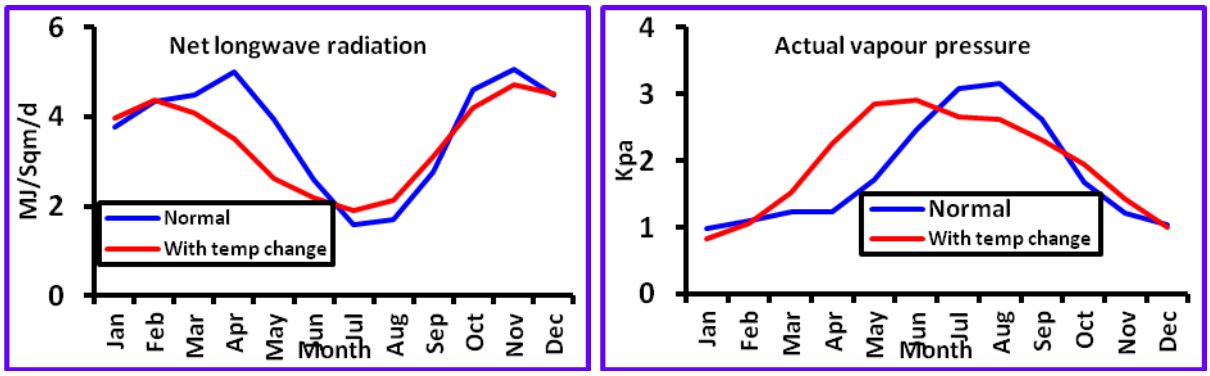


Fig. 2: Expected variation in various temperature dependent parameters due to 1^0C change in temperature

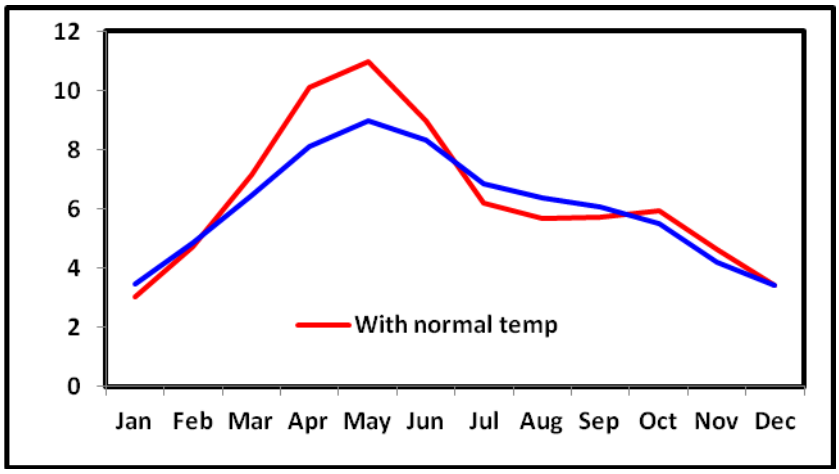


Fig. 3: Normal evaporation versus evaporation with assumed 1^0 C increase in temperature at Chandigarh

The results obtained for the humid region of Chandigarh have been compared with the semi-arid region of Udaipur. Fig. 4 shows a comparison of change in open water surface evaporation at Udaipur and Chandigarh due to assumed 1^0 C hypothetical increase in normal temperature at these locations. It can be observed that there is a variation in the pattern of expected change at the two stations. Thus, while there is an expected increase in evaporation at Chandigarh during February, a decrease is expected at Udaipur in this month. During June and October, a reverse situation is expected. Thus, increase is expected in evaporation at Udaipur and decrease is expected at Chandigarh during these months. The pattern of change in evaporation is same for the remaining months. Thus, there is a projected decrease in evaporation during the summer months of March, April and June as well as during November at both the stations. Similarly, evaporation is expected to increase during the monsoon months at both the stations.

Further, it has been observed that there is a quantitative difference in the expected variation at the two stations (Fig. 4). At Udaipur, the expected change in evaporation is much smaller during the warmer months of March, April and May. The changes are 3.12%, 3.9% and 2.19 % respectively for these months. Comparatively, the changes are much more pronounced at Chandigarh. The respective changes at Chandigarh are 9.87%, 19.72% and 18.24%. Both the stations show significant

variations during the monsoon months of July to September, but changes at the semi-arid station of Udaipur are much higher compared to humid Chandigarh. The expected change for the months of July, August and September are respectively 15.41%, 23.57% and 13.15% at Udaipur and respectively 11.07%, 12.7% and 6.35 % at Chandigarh. The changes at both the stations are due to expected variation in the vapour pressure deficit regime.

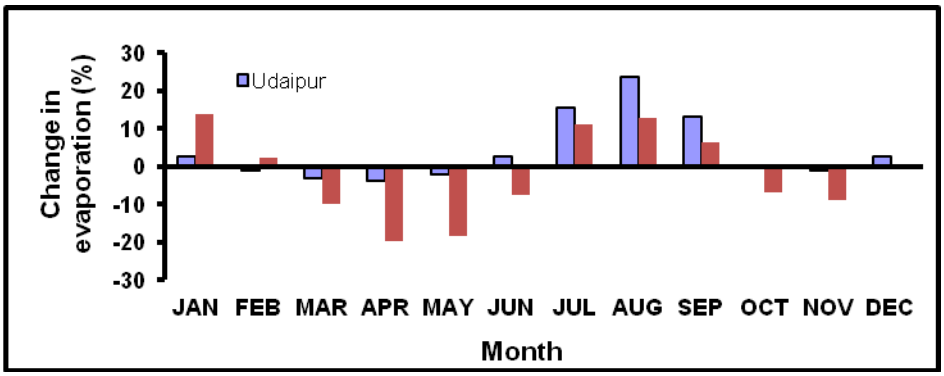


Fig 3: Comparison of change in evaporation at Udaipur and Chandigarh due to assumed 1^0 C increase in normal temperature

Adopters of the results of the study and their feedback:

Water resources managers, as well as researchers working in the area of climate change

List of deliverables:

Projected rates of evaporation for different assumed rise of temperatures for different climatic regions of India, report, papers, methodology

Major items of equipment procured: None

Lab facilities used during the study: None

Data procured and/or generated during the study: Meteorological data already available for Udaipur and Chandigarh stations have been used so far. Additional data for these stations as well as for other stations are being procured.

Study Benefits/Impact:

In view of the climate change, the study would provide projected rates of evaporation for different assumed rise of temperatures for different climatic regions of India.

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

The output from the study is expected to assist the water resources planners/managers in planning/managing future demands from open surface water bodies such as lakes and reservoirs by providing them with projected rates of evaporation for the regions.

Shortcomings / difficulties, if any: None so far

Future plan: The study is to be carried out for few more regions of India.

Annexure - 4

ACTIVITY SCHEDULE FOR ASSESSMENT OF SENSITIVITY OF OPEN WATER EVAPORATION TO INCREASE IN TEMPERATURE FOR DIFFERENT CLIMATIC REGIONS OF INDIA

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

5. REFERENCE NUMBER: NIH/HID/INT/2012-14/2

Title of the study: **WATER QUALITY, HYDROGEOLOGY AND ISOTOPIC INVESTIGATIONS IN SW PUNJAB**

Name of PI, Co-PI and their affiliations: Dr. M. S. Rao (PI)
Mr. C. P. Kumar
Dr. Gopal Krishan

Type of study: Internal

Date of start, Scheduled date of completion: July 2012 to June 2014

Location map:

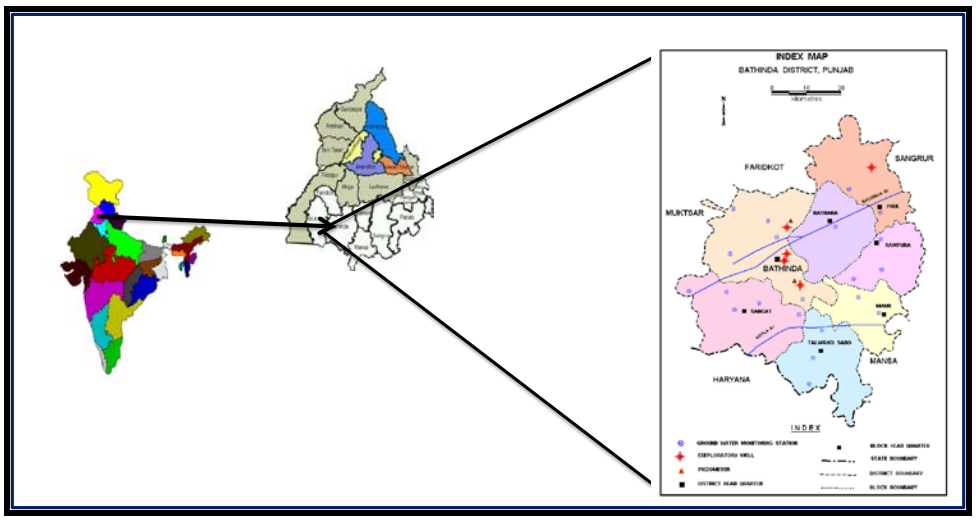


Fig 1. Study area

Study objectives:

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

Statement of the problem:

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

Action plan:

Year	**April 2013 to June 2014** (Annexure 5)	Remark
Apr 2013 to June 2014	Groundwater inventory Identifying the sampling sites for isotopic and water quality analysis Data collection Water sampling, analysis and data interpretation Report writing	Report preparation as per Annexure 5

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

2-column table showing objectives vis-à-vis achievements:

Objectives	Status	Work Done
To investigate the water quality in multi-aquifer system of Bhatinda and neighbouring area	In progress	A field work was carried out and collected 20 samples for analysis of stable isotopes and water quality for which analysis work is in progress.
Evaluation of groundwater quality in accordance with its source of origin and age	In progress	A map was prepared on the basis of EC of the water samples and the results for other parameters will be shown in the Working Group presentation.

Analysis and Results:

A field work was carried out to do the survey of the study area and 20 random samples were collected. At 3 sites, the EC was found to be less than 1000 µS/cm. The EC was found to be more than 1000 µS/cm in 17 locations and out of which, at 7 locations the EC was found to be more than 2000 µS/cm as shown in Fig. 2. Investigation of ions (anions and cations) contributing towards increased EC using Ion Chromatograph is in progress.

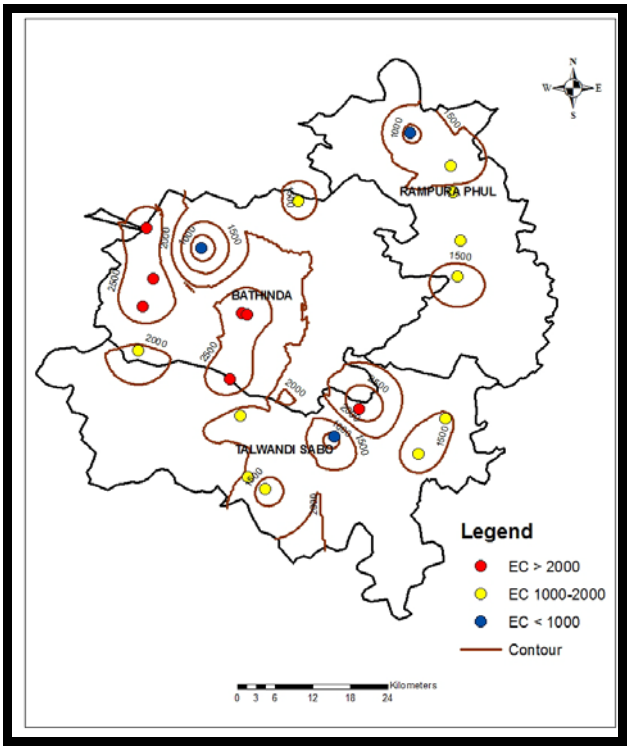


Fig 2. EC contours-map (post-monsoon, 2012) of groundwater in Bhatinda district

Study Benefits / Impact:

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

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

Department of Geology, Punjab University, Chandigarh

Data requirement & expected source:

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

IPR potential and issues: NIL

Major items of equipment needed: None

Future plan:

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

Annexure – 5

ACTIVITY SCHEDULE FOR WATER QUALITY, HYDROGEOLOGY AND ISOTOPIC INVESTIGATIONS IN SW PUNJAB (QUARTER WISE: APRIL 2013 TO JUNE 2014)

Activity	1st	2nd	3rd	4th	5th
Sampling (groundwater, surface water, precipitation)	♦		♦		
Collection of data	♦	♦	♦		
Isotopic analysis (δD and $\delta^{18}O$) of samples	♦	♦	♦		
Water quality analysis of surface water and groundwater samples	♦	♦	♦		
Annual report		♦	♦		
Interim report			♦	♦	
Publications and reporting in conferences			♦	♦	♦
Final report				♦	♦

6. REFERENCE NUMBER: NIH/HID/DST/2007-13

Title of the study : **NATIONAL PROGRAM ON ISOTOPE FINGERPRINTING OF WATERS OF INDIA (IWIN)**

Name of PI and his affiliations: Dr. M. S. Rao (PI)

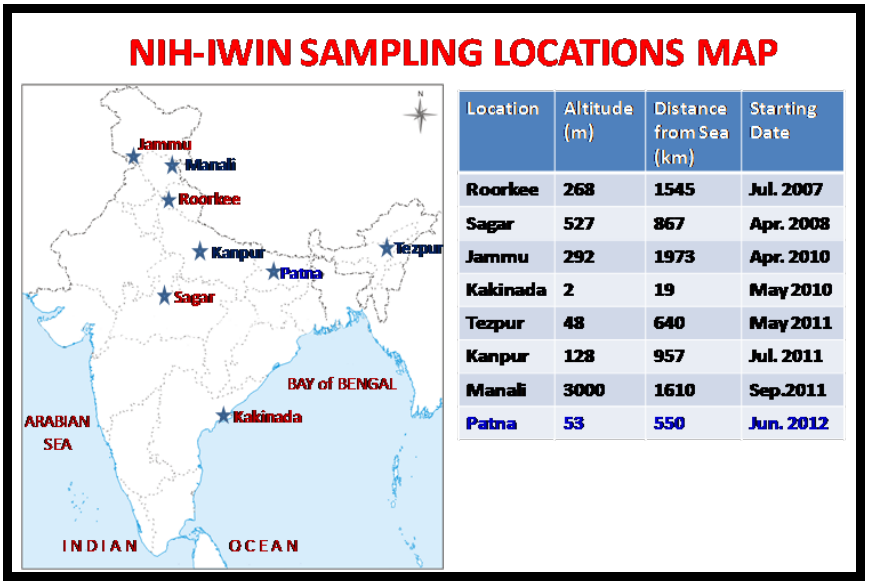
Type of study : Sponsored (funded by DST vide IR/54/ESF/05-2004 dated July 17, 2007)

Date of start: July, 2007

Scheduled date of completion: 19-07-2013

Location map:

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



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

Study objectives (NIH+IWIN members):

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

Statement of the problem:

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

Approved action plan

Year	April 2013 to June 2013 (Annexure 6)	Remark
April 2013 - June 2013	**Sampling (from network of stations to achieve the objectives of the project)**: **At Roorkee**: (1) Rain (event based), (2) ground level vapour (GLV) by Condensation and P&T methods (daily), (3) groundwater and (4) surface water (River Ganga) **At Sagar***: Items 1-3 as at Roorkee (GLV by cond.) **At Jammu**: Items 1-3 as at Roorkee (GLV by cond.) **At Kakinada**: Items 1-2 as at Roorkee (GLV by cond.) **At Tezpur University**: Item 2 as at Roorkee (GLV by cond.) **At IIT-Kanpur**: Item 2 as at Roorkee (GLV by cond.) **At MMHP, Manali(HP)**: Items 2 as at Roorkee (GLV by cond.) **At Patna**: Item 2 as at Roorkee (GLV by cond.) **Data Collection**: Hydro-meteorological at Roorkee, Sagar, Jammu, Kakinada, Tezpur, Kanpur, Manali and Patna. **Analysis**: Analysis of water samples (NIH, Sagar, Jammu, Kakinada, Tezpur, Kanpur, Manali & Patna) and samples provided by participating organizations for δD, $\delta^{18}O$ and ^{3}H. **Data interpretation** **Final Report writing** ***Due to the shifting of Sagar Regional Centre from Sagar to Bhopal, the samples will also be collected from Bhopal	Report preparation as per Annexure 6

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

2-column table showing objectives vis-à-vis achievements

Objective	Status	Work Done
Identifying regional/local water vapour components in the local atmosphere Identifying dominant sources of water vapour supply (Arabian sea/ Bay of Bengal/local and long distant continental sources) during different seasons	Achieved	Characterized the continental moisture (AS, BoB), regional moisture (Ganga basin), local moisture (at individual locations). Use of soft-computing technique for component mass balancing is in progress and will be completed in time. The interpretation for the local moisture dynamics has been supported with Rose Plots for wind pattern analysis.
Isotopic database development	In progress	Isotopic database has been developed for approximately 23000 samples =9200 (NIH) + 13800 (PRL)

Recommendations/suggestion in previous meeting of Working Group

Suggestion by Dr. R.D. Deshpande: Find out the sources at Kakinada using the meteorological parameters.
Action Taken: Meteorological data from RC, Kakinada for the period 2007 to 2011 has been collected in January 2013.

Analysis and Results

- Collected 980 samples since October 2012 and sample analysis work is in progress.
- Isotopic characteristic ($\delta^{18}O$) of moisture from various sources:
  -15‰ corresponding to the Western Disturbances
  -20‰ Bay of Bengal and Arabian Sea
  -11‰ corresponding to local/regional vapours

At Roorkee, the vapours are characterized for different seasons as:

Monsoon vapour: $\delta D=6.29\delta^{18}O+32.80$; $R^2=0.88$
Local vapour : $\delta D=4.83\delta^{18}O+28.17$; $R^2=0.80$
W.D. vapour : $\delta D=5.38\delta^{18}O+30.38$; $R^2=0.73$

To understand influence of different moisture sources, it is important to know moisture flux and wind direction in the study area. The horizontal moisture flux in the study area was calculated using the formula given as:

where q_{lvl}, are the specific humidity and horizontal velocities at a given level i.e. at ground level. Pre-monsoon and winter period shows enriched nature except for few samples which may be due to downdraft of convective clouds.

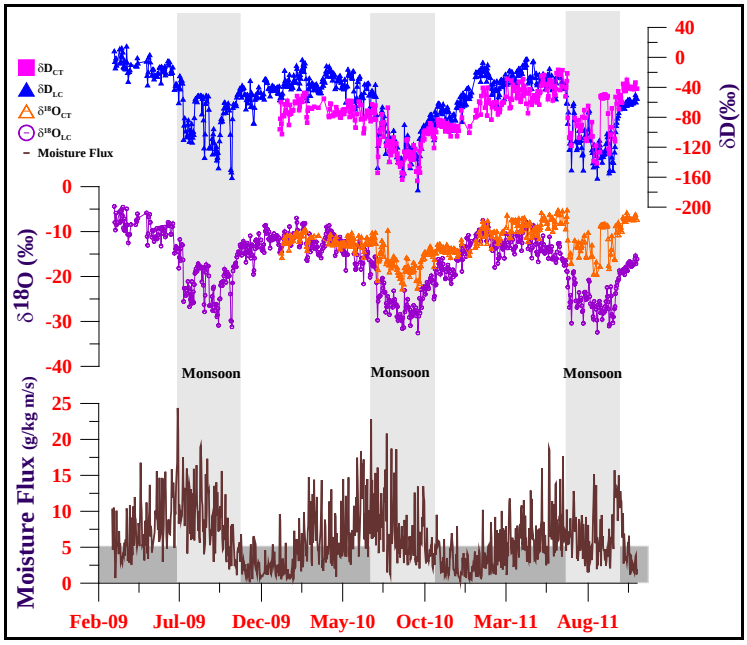


Figure 1. Time series plot of stable isotopes and moisture flux at Roorkee

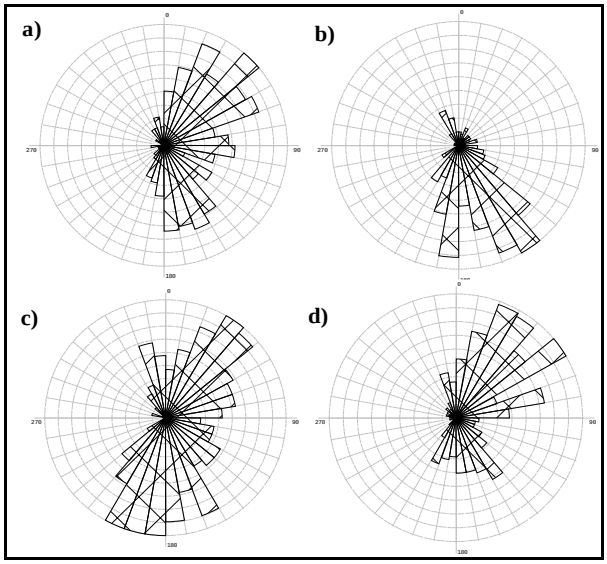


Figure 2. Rose plot of Wind Direction in the study area during sampling time (9:00 to 16:00 hrs) – (a) Pre monsoon, (b) Monsoon, (c) Post monsoon, (d) Winter

Also, in these periods, the study area is dominated by western disturbances which is evident from high moisture flux (>7.5g/kg m/s) (Fig. 1) and from wind direction (N-NE direction; Fig. 2a & d) indicating entering of westerlies diverted by the Himalayas. Highly depleted nature of GLV during monsoon period is due to moisture source outside the study area which is evident from high moisture flux (>7.5g/kg m/s) (Fig. 1). This moisture source is mainly from the oceanic region, especially southwest monsoon, which is clearly visible from the wind direction entering the study area i.e. SW-NE (Fig. 2b).

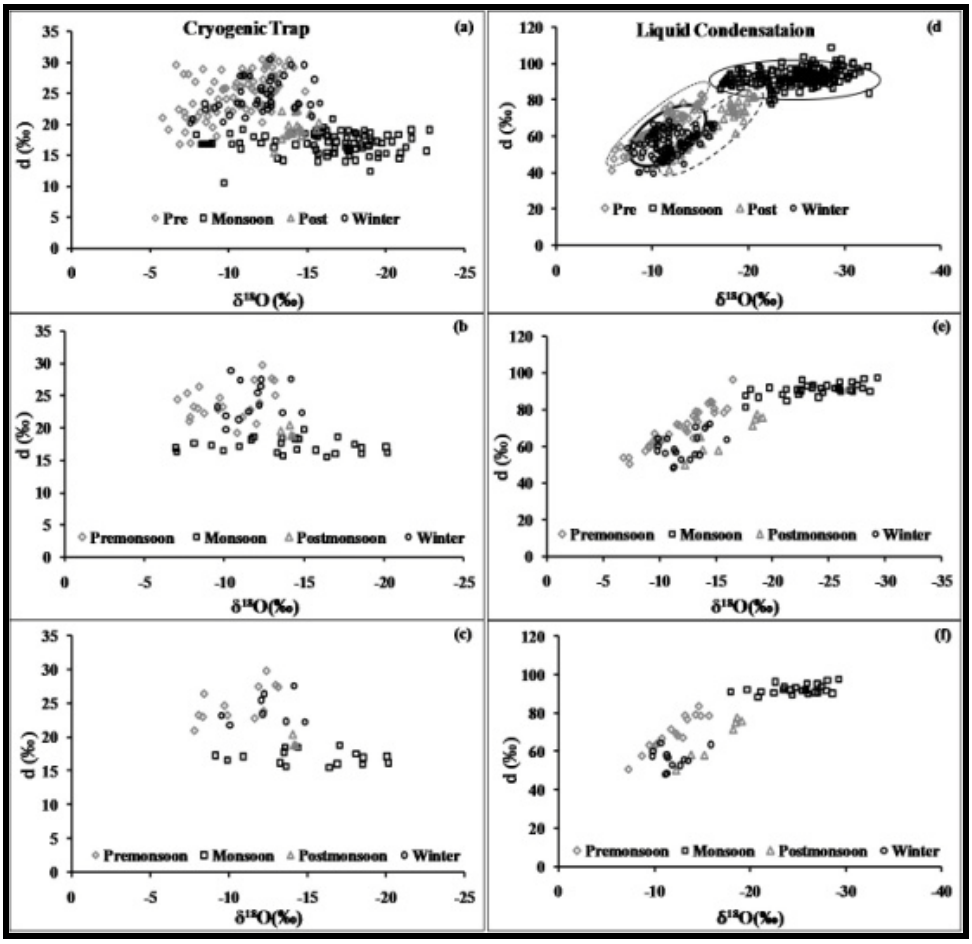


Figure 3. $\delta^{18}O$ vs d-excess (d) bi-plot of ground level vapour- (a-c) Cryogenic trap (d-f) liquid condensation. (a&d) daily water vapor isotopic composition; (b&e) 10 daily average of water vapour composition; (c&f) peak seasonal data (10 daily average of water vapour composition)

The GLV_{CT} daily samples (Fig. 3a) exhibits highly scattered behaviour with lower d & $\delta^{18}O$ during monsoon period and higher d & $\delta^{18}O$ during winter and pre-monsoon periods. The $GLVL_{LC}$ daily samples (Fig. 3d) exhibits poor correlation with high d value during monsoon period and lower d value during winter period. The pre-monsoon and post-monsoon periods show an increasing d value and lower $\delta^{18}O$ which merges with the monsoon $\delta^{18}O$ values.

The study area experiences extreme climate, very cold during winter and very hot during summer (pre-monsoon) and decreasing temperature during post-monsoon period, thereby resulting in change of both meteorological parameters and isotopic composition of GLV.

Adopters of the results of the study and their feedback:

The IWIN project is a national level program and in which various academic institutions, national level organizations including MoWR are participating. A network of stations has been developed and the results of the study are commonly getting shared. The program is also generating papers in high impact journals and through

which the knowledge will be transpired to various other institutions nationally and globally.

List of deliverables:

Publications :
Total Publications (2007-2012) =16
(Journals- 5; Conferences: International-5; National-5; Book Chapter-1)
Publications (Oct. 2012 to Mar. 2013) = 6
(Journals-2; Conferences-3; Book Chapter-1)

- Krishan, Gopal, Rao, M. S. and Kumar, C. P. 2013. Application of isotopes of water vapour in climate studies – A world perspective. In: Climate Change and Himalayan Ecosystem Indicator, Bio and Water Resources. (Eds. J. Sunderasan, Pankaj Gupta, K. M. Santosh and Ram Bhoojh. Scientific Publishers, India, **10: 119-127**.

- Krishan, Gopal**,** Rao, M. S., Garg, Pankaj and Kumar C. P. 2013. Roorkee Kshetra mein jalvayu addhyan ke liye vayu mein nami ki garna mein samsthanik hastakashar ka upyog. In: 3rd National conference on Innovations in Science, Engineering and Technology during 25-27 February, 2013 at NPL, New Delhi pp: **238**.

- Krishan, Gopal**,** Rao, M. S., and Kumar, Bhishm. 2012. Study of climatological conditions using isotopic signature of air moisture at Roorkee, Uttarakhand, India. NDC-WWC Journal. **1 (2):3-7**.

- Rao, M. S.; Krishan, Gopal; Kataria, Prateek and Kumar, C. P. 2012. Assessment of Hydrological interaction between canal and groundwater at Roorkee using isotopes and hydro-chemistry. In: 30th and 31st AHI Annual Conventions & National Seminar on Hydrology during Dec. 11-12, 2012 at Centre for Applied Geology, Gandhigram Rural Institute - Deemed University, Dindigul Dist., Tamil Nadu, pp. **71-72**.

- Krishan, Gopal, Rao, M. S., Kumar, C. P., Kumar, Bhishm and Thayyen, Renoj J. 2012. Stable Isotope (δ) technique to identify South West monsoon at Roorkee and Jammu. In: National Symposium on “Progress in Electronics and Allied Sciences” (PEAS-2012) during 03-04 November, 2012 at Gurukul Kangri University, Haridwar, India pp. **65**.

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

Major items of equipment procured: Nil

Lab facilities used during the study: Hydrological Investigations Division

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

Study Benefits / Impact:

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

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

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

Shortcomings/difficulties, if any : Nil

Future plan :

- The sampling of GLV, rain, river and groundwater will continue upto June, 2013 including Bhopal.
- Since, the project has brought out the importance of isotopic characteristic of moisture in climate studies, it is proposed to continue the air moisture sampling at Kakinada, Bhopal, Roorkee and Jammu as an integral part of National Climate Study with coordinating centre at Roorkee with NIH R&D plan grant. Towards this, a new laser based isotopic analyser is planned to be purchased which will be used for regular analysis of these samples.
- Scientific/technical publication/reporting will be continued.

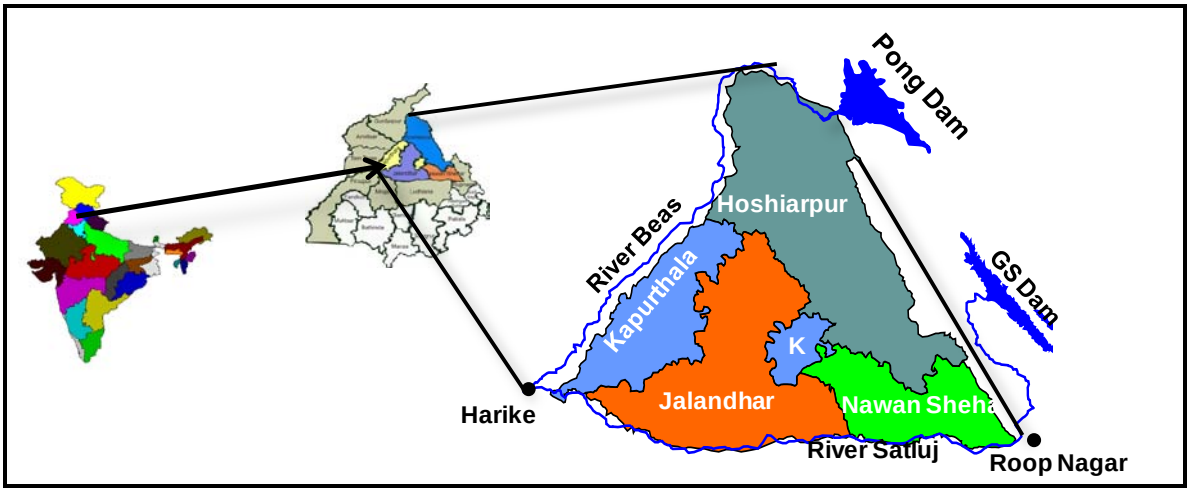
Annexure – 6

ACTIVITY SCHEDULE FOR NATIONAL PROGRAM ON ISOTOPE FINGERPRINTING OF WATERS OF INDIA (APRIL 2013 TO JUNE 2013)

Activity	
Sampling from all stations (8) of NIH (air moisture, groundwater, precipitation)	♦
Collection of data from IMD	♦
Isotopic analysis (δD and $\delta^{18}O$) of samples	♦
Water quality analysis of SW and GW samples	♦
Isotopic analysis (δD and $\delta^{18}O$) of SW and GW samples	♦
First Draft Report	♦
Second Draft Report	♦
Final Report	♦

7. REFERENCE NUMBER: NIH/HID/HP-II/2008-13

1	**Title of the study**	:	**GROUNDWATER DYNAMICS OF BIST DOAB AREA, PUNJAB USING ISOTOPES**
2	**Name of PI, Co-PI, & their affiliations**	:	Dr. M. S. Rao (PI)
3	**Type of study (sponsored /consultancy /referred /internal). If referred, mention the reference**	:	Sponsored PDS under HP-II
4	**Date of start, Scheduled date of completion**	:	October 2008 December 2013
5	**Location map (wherever applicable)**	:	The Bist Doab is a triangular region and covers an area of 9060 km^2. The area lies between 30^{0}51' and 30^{0}04' N latitude and 74^{0}57' and 76^{0}40' E longitude. It comprises the districts Hoshiarpur, Kapurthala, Jalandhar and Nawanshahar districts and part of the district Roop Nagar of Punjab State, India. It is bounded by Shiwaliks in the north-east, the river Beas in the north east-south west and the river Satluj in south east-south west. The area is drained by the perennial rivers Satluj and Beas and their tributaries. They coalesce at the Harike. The climate of the area is influenced by the Himalayas in the north.



6	**Study objectives**	:	Identifying groundwater recharge zone and recharge sources using groundwater dating and stable isotope technique Groundwater modelling

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

8 Approved action plan : Please see Annexure 7

9 Timeline and justification for time over runs : NA

10 2-column table showing objectives vis-à-vis achievements :

Objective	Status	Work Done
Identifying groundwater recharge zone and recharge sources using groundwater dating and stable isotope technique and groundwater modelling	Recharge sources and zones of shallow and deep groundwater have been refined.	***Stable Isotopes & Environmental Tritium:*** 716 samples (SW, GW and Rain) have been collected from October 2012 to March 2013 making total of 4477 (4477 stable isotope and 170 environmental tritium) samples collected during the entire study period. *Status of Sample Analysis:* No sample could get analysed since last Working Group meeting for stable isotope or environmental tritium dating mainly due to over loading of sample analysis for various studies and projects (and partly due to non-functioning of instrument for some time). As on date, 1420 samples for stable isotopes and 90 samples for environmental tritium are pending for analysis. ***Water Chemistry:*** The groundwater samples collected during pre & post monsoon periods of 2011 have been analysed for water quality using Ion Chromatograph, interpretation of data has been carried out (these results will be presented in the working group). The analysis of groundwater samples collected (116) during Jan. 2013 for water chemistry is in progress.
	In progress	Analyses of water samples for stable isotopes, environmental tritium, carbon dating and water quality.

11 Recommendations/suggestions in previous : Nil

meetings of Working Group/TAC/GB should be mentioned along with the action taken

12 **Analysis and Results :**

WATER QUALITY

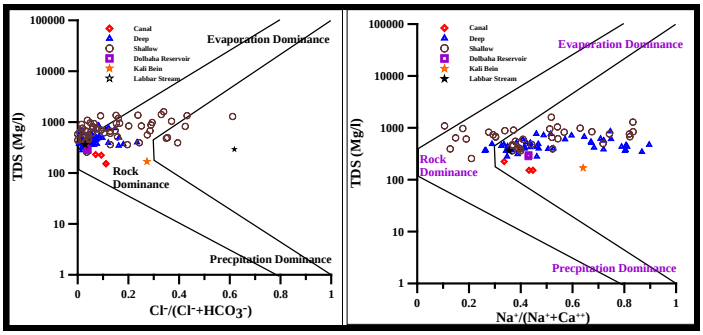
Major Ion

Chemistry in surface water and groundwater has been examined. The following relative concentrations are observed.

Sources	Water Quality	Water Type
Surface water	$Mg^{2+}>Ca^{2+}>Na^{+}>K^{+}$	Canal: $Mg^{2+}HCO_3^-$ Reservoir: $Mg^{2+}>Ca^{2+}>Na^{+}>K^{+}$
Groundwater	$Na^{+}>Ca^{2+}>Mg^{2+}>K^{+}$	Southwestern part: $Na^{+}HCO_3^-$ Other Part: Mg^{2+} (Ca^{2+} Na^{+}) HCO_3^-

Hydrogeochemical Processes dominating Water Chemistry

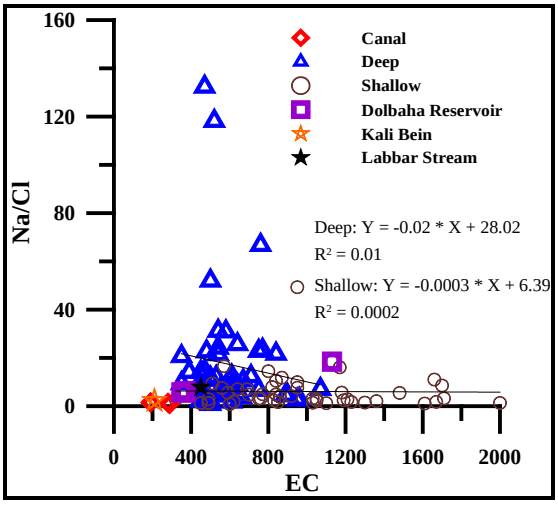
In the study area, water chemistry is controlled mainly by rock water interaction of recharge zone and aquifer matrix. The high concentration of sodium in groundwater in south-western part of study area shows influence of sodic rich minerals (like plagioclase feldspars) and influence of evaporation of percolating rain water. This is resolved using the Na/Cl vs EC plot (discussed below).



Evaporation of Groundwater

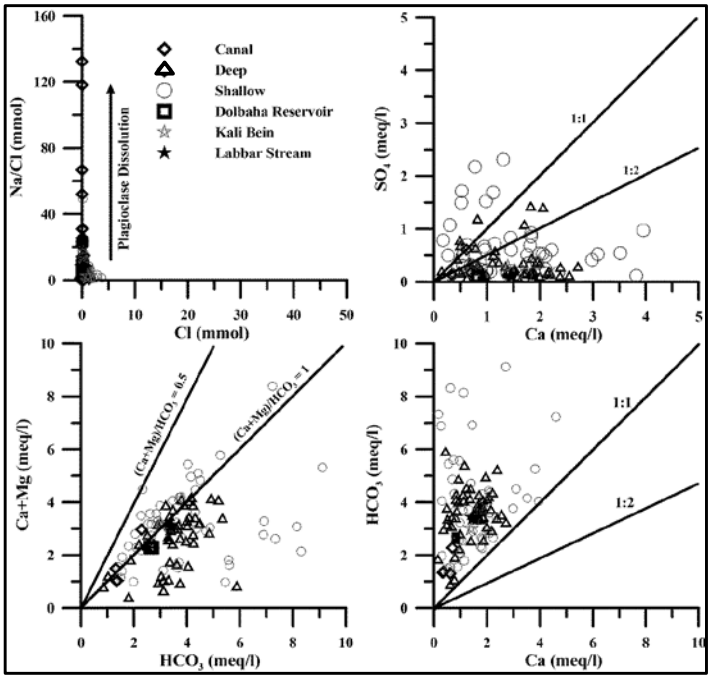
Shallow groundwater shows the concentration of groundwater due to evaporation and evapo-transpiration.

Deep groundwater shows that concentration is mainly influenced by the water rock interaction.



Weathering and Dissolution

The Na^+/Cl^- vs Cl^- plot shows increasing Na concentration without any significant change in Cl^- which indicates that increase in Na^+ is mainly due to dissolution of plagioclase as the major source for groundwater chemistry in the study area. All location plot near Ca^{2+} axes in Ca^{2+} vs SO_4^{2-} indicates negligible amount of gypsum in the study area. 1:1 equiline of $Ca^{2+}+Mg^{2+}$ vs HCO_3^- plot shows dominance of silicate/carbonate weathering. The plot shows all the locations fall near HCO_3^- indicating dominance of silicate weathering. The Ca^{2+} vs HCO_3^- plot shows all locations fall above 1:1 line indicating dissolution of calcite.



Drinking and Irrigation Water Quality

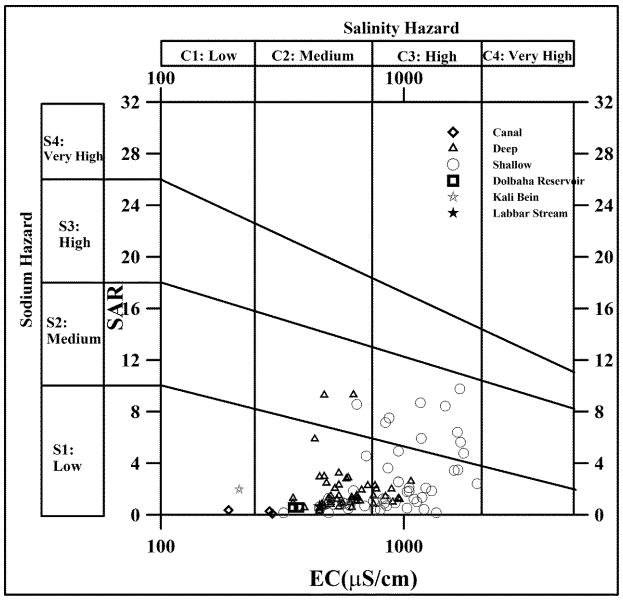
Shallow groundwater shows high concentration of cations at few locations (above desirable/ permissible limit) (Table), whereas deep groundwater shows very good quality w.r.t cations.

Except fluoride and nitrate, all other anions show concentration within permissible limit in both shallow and deep groundwater. Fluoride shows high concentration in central part of the study area. Nitrate shows high concentration only in

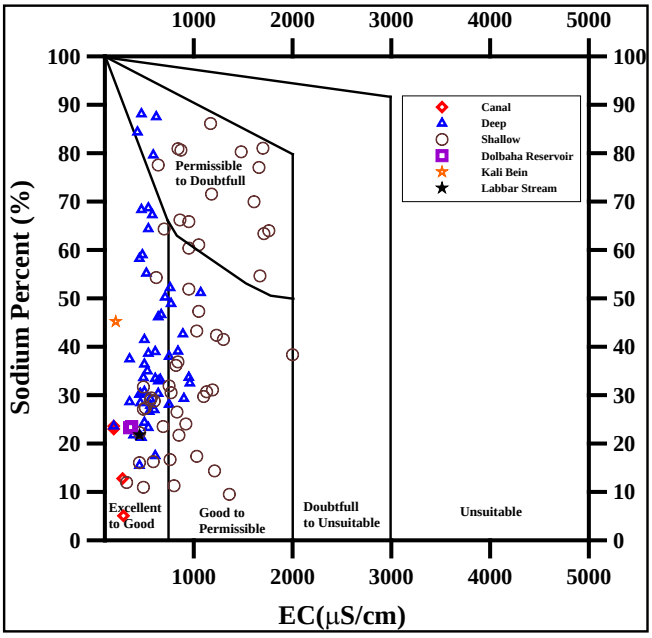
Ions	Shallow	Deep
Ca^{2+} (>75mg/l)	Rahon, Badesaron	All samples within permissible limit
Mg^{2+} (>30mg/l)	Goraya, Noormahal, Rahon, Saidpur Jhinni, Nakodar, Nawanpind	
Na^+ (>200mg/l)	Phillaur, Sadiqpur	
K^+ (>10mg/l)	Begowal, Maliyakalan	
F^-		
Above desirable limit (0.6-1.2mg/l)	Busowal, Darwesh, Jandiala, Khurdpur	Darwesh, Malliankalan, Arjanwal, Phuller
Above permissible limit (>1.2mg/l)	Jalandhar	Behram
NO_3^- (>45mg/l)	Nussi, Nakodar, Goraya, Nawanpind	All samples within permissible limit

Values in parenthesis indicate drinking water quality (BIS & WHO)

shallow groundwater which might be due to influence of fertilizers.
Drinking water quality w.r.t. EC shows that most of the shallow groundwater and few deep groundwater has high salinity hazard resulting in change in the taste of water.
Sodium hazard of groundwater shows that shallow groundwater at few locations exhibit medium hazard which results in deterioration of permeability of soils



Shallow groundwater at few locations shows permissible to doubtful water quality with respect to irrigation indicating high amount of sodium affecting soil matrix of the study area.



13 **Adopters of the results of the study and their feedback** : CGWB (NWR), Chandigarh; Punjab Water Resources Development & Management; and Punjab Water Resources & Environment Directorate, Chandigarh

14 **List of deliverables (e.g. equipment, papers, reports, software, manuals, brochures, flyers, training programmes, users interaction workshops)** : **Papers Published** (Journals: 1, Conferences: 2)

Drinking and irrigation water quality in Jalandhar & Kapurthala districts, Punjab, India. (2012) International Journal of Earth Science & Engineering, Vol. 5: 1599-1608.

Use of isotopic techniques in identification of groundwater recharge sources: Some case studies from India. National Seminar on Hydrology "HYDROCARE- 2012, 11th to 12th

December 2012.
Ground water crisis and remediation in Punjab, India, ICIESMS-2013, during 22-23 February 2013 at Madurai.
Water resources management and artificial groundwater recharge measures in Bist-Doab region, India. Accepted for the presentation in India Water Week- 2013 to be held at New Delhi during 8–12 April, 2013.
Impact of climate change on agricultural productivity in Punjab, India. Accepted for the presentation in ICCC-2013, to be held at Tiruchirappalli during 23-27 April 2013.

15 **Major items of equipment procured** : Nil

16 **Lab facilities used during the study** : Laboratory facility at the division has been utilized.

17 **Data procured and/or generated during the study** : Entire isotopic data has been generated through field sampling and their laboratory analysis. Water level data generated through AWLR installed at peizometers at 6 locations in the study area.

18 **Study Benefits / Impact** : The study is getting progress in association with PWR&ED and CGWB. Both the departments will be benefitted through the study results.

19 **Specific linkages with Institutions and/or end-users/beneficiaries** : CGWB (NWR), Chandigarh; Punjab Water Resources Development & Management; Punjab Water Resources & Environment Directorate, Chandigarh; Punjab Water Supply and Sanitation Department, Jalandhar.

20 **Shortcomings / difficulties, if any** : Aquifer specific water sampling from deep piezometers
Water quality data of the study region (other than southwestern region) is yet to be received from CGWB.

21 **Future plan** :
- Analysis of 1420 samples which were collected from March 2012 to February 2013 for stable isotopes
- Analysis of GW, SW samples for environmental tritium and Carbon-14 dating
- Analysis of 200 samples for groundwater chemistry
- Construction of deep peizometers
- Aquifer disposition map
- Final Report and publication of research articles in journals & conferences.

Annexure- 7

ACTIVITY SCHEDULE FOR GROUNDWATER DYNAMICS OF BIST DOAB AREA, PUNJAB, USING ISOTOPES

Activity	2013			
Month/Quarter →	1st	2nd	3rd	4th
Sample collection of groundwater, surface water, precipitation	✔	✔		
Surface water and groundwater data processing	✔	✔	✔	
Construction and installation of piezometers at 6 locations (3 at Kandi and 3 at plain region) and water sampling & analysis	✔	✔	✔	
Identification of recharge zones and recharge sources.	✔			
Integration of water quality, stable & radioactive isotope data and field data along with modelling to develop a general scenario for groundwater flow in aquifers		✔	✔	
Publications & reporting in conferences	✔	✔	✔	✔
Preparation of final report			✔	✔

8. REFERENCE NUMBER: NIH/HID/HP-II/2008-14

Title of the study: **GROUNDWATER MANAGEMENT IN OVER-EXPLOITED BLOCKS OF CHITRADURGA AND TUMKUR DISTRICTS OF KARNATAKA**

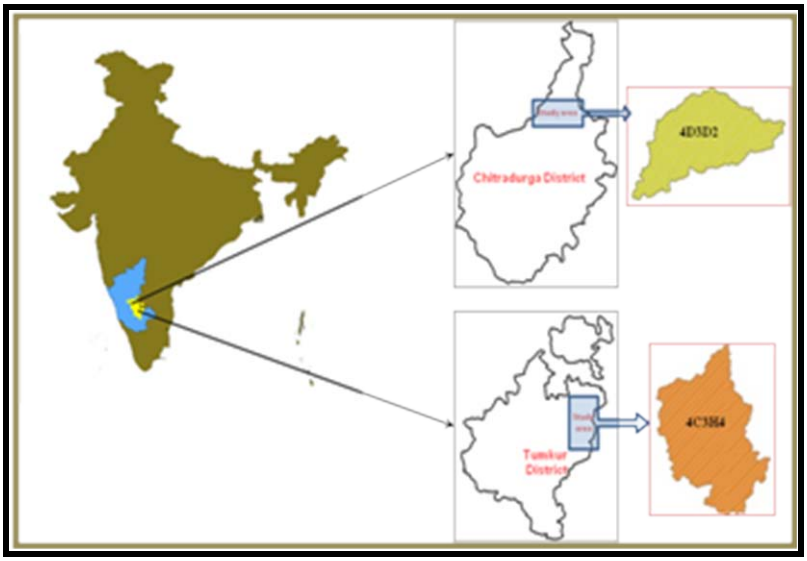
Name of PI, Co-PI, & their affiliations: Dr. Sudhir Kumar (PI)
Dr. J. V. Tyagi
Dr. S. P. Rai
Dr. Anupma Sharma
Dr. B. K. Purandara (HRRC, Belgaum)
Prof. C. Rangraj (SSIT, Tumkur)

Type of study: Sponsored (PDS under HP-II)

Date of start, scheduled date of completion:

Start Date: October 2008
Expected end date: March 2014

Location map (wherever applicable):



Study objectives:

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

iv) To identify anthropogenic interventions and evaluate their likely impact for effective groundwater management.
v) To arrive at a model for management and regulation of identified over-exploited blocks on an operational basis.

Statement of the problem:

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

Approved action plan: Please see Annexure 8.

Timeline and justification for time over runs:

The procurement of data and instruments has delayed the work schedule. Non availability of adequate and reliable historical hydrological data has hampered the analysis work.

2-column table showing objectives vis-à-vis achievements:

Objectives	Achievement
To analyze groundwater productivity at specific study sites including artificial recharge structures and an assessment of potential increases and their contribution to rural livelihood improvement.	Work in progress
To develop integrated understanding of hydrologic, social, economic, and institutional perspectives.	Work in progress
To improve stakeholder engagement and community participation for developing a common vision, goal and partnership for managing basin's groundwater resources.	Work in progress
To identify anthropogenic interventions and evaluate their likely impact for effective groundwater management.	Work in progress
To arrive at a model for management and regulation of identified over-exploited blocks on an operational basis.	Work in progress

Recommendations/suggestions in previous meetings of Working Group/TAC:

No specific comments were made by either Working Group or TAC.

Analysis and Results

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

Adopters of the results of the study and their feedback: Karnataka Government, the States with hard rock aquifers.

List of deliverables: Report, papers, methodology, brochure and training program.

Major items of equipment procured: Automatic Rain Gauges, Evaporation Pan, Soil Moisture Probes, Automatic Groundwater Level Recorders.

Lab facilities used during the study: Isotope laboratory, Soil Water laboratory and Hydrological Instrumentation laboratory.

Data procured and/or generated during the study:

Procured: Remote sensing data from NRSC, and Geological maps of the area from GSI
Generated: Isotopic data and aquifer parameters of the aquifers

Study Benefits/Impact: Some scientific knowledge and data about hydrology of hard rock area, particularly granitic areas of India.

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

The output from the study is expected to provide policy guidelines for developing, managing and regulating groundwater resources on a sustainable basis for over exploited regions.

Shortcomings / difficulties, if any: Delay in procurement of data and instruments, lack of historical data and reliability of data.

Future plan: Compilation and finalization of the report

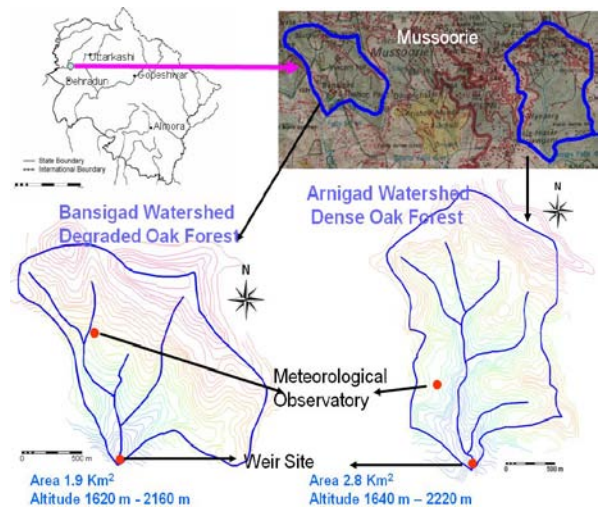
Annexure - 8

ACTIVITY SCHEDULE FOR GROUNDWATER MANAGEMENT IN OVER-EXPLOITED BLOCKS OF CHITRADURGA AND TUMKUR DISTRICTS OF KARNATAKA

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

9. REFERENCE NUMBER: NIH/HID/FRI/2008-13

1	**Title of the study**	:	**IMPACT ASSESSMENT OF LANDUSE ON THE HYDROLOGIC REGIME IN THE SELECTED MICRO-WATERSHEDS IN LESSER HIMALAYAS, UTTARAKHAND**
2	**Name of PI, Co-PI, & their affiliations**	:	Dr. S. P. Rai (PI) Dr. J. V. Tyagi Mr. M. P. Singh, FRI Mr. Rajeev Tiwari, IGNA Mr. Vishal Gupta Mr. Jamil Ahmad Mr. V. K. Agarwal
3	**Type of study (sponsored/ consultancy/ referred/**	:	Collaborative with FRI, Dehradun Rs. 3 lac (NIH Component)
4	**Date of start, scheduled date of completion**	:	April 2008 to March 2013
5	**Location map (wherever applicable)**		



Area of watershed Arnigad Bansigad	 ~3 km^2 ~2 km^2
Landuse Arnigad Forest Cover (Dense Oak) Bansigad Forest Cover (Sparsed Mixed)	 86% 65%
Geology of both watersheds	Similar
Geomorphology	Almost similar
Altitude variation Arnigad Bansigad	 1640-2220 m 1620-2160 m

6	**Study objectives**	• Impact of forest cover on stream discharge pattern

- To separate surface runoff and groundwater components in the stream discharge using conventional and isotopic techniques
- Soil erosion under different forest cover
- Identification of recharge zones of stream and springs using isotopic technique

7 **Statement of the problem**

Efforts to understand hydrology of the Himalayan region and impact of forests on watershed level are limited. Studies on hydrology of the Himalayan mountains have made it clear that the hydrological research conducted in this region so far is inadequate to conclude the impact of forest cover. Major studies conducted at the experimental plot do not necessarily hold true at the catchments scale. Mainly, the studies conducted on plot scale or small catchments of only a few hectares lack the continuous data of all extreme conditions so that unusual storm events are often not included in the study period. The impact of forests, which cover the head-waters of many of the major river systems of the Indo-Gangetic plains, could not be studied, mainly because of difficult terrain conditions and other logistical problems.

Therefore, to study the impact of forest cover on hydrology of Himalayan watersheds, this study was started in collaboration with Forest Research Institute, Dehradun.

8 **Approved action plan** **:** Please see Annexure 9.

9 **Timeline and justification** for time over runs **:** March 2013

10 **2-column table showing objectives vis-à-vis achievements** **:**

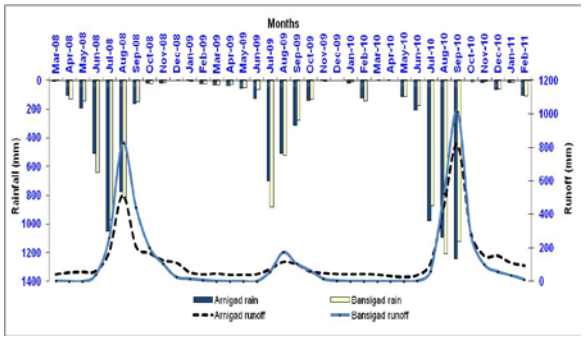
Objectives	Achievements
Impact of forest cover on stream discharge pattern	Data collection and analysis completed
To separate surface runoff and groundwater components in the stream discharge using conventional and isotopic techniques	Separation of base flow and surface runoff component completed
Soil erosion under different forest covers	Data analysis completed

Identification of recharge zones of stream and springs using isotopic technique	Isotope technique has been used to identify the recharge zones of streams

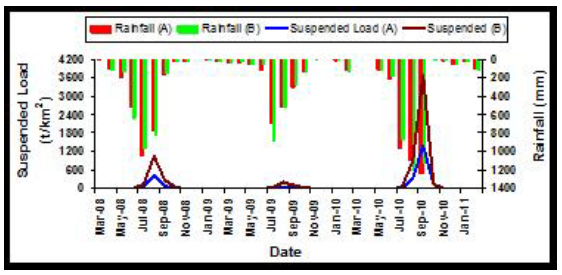
11 **Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken** : NIL

12 **Analysis and Results** :

- The estimated average runoff coefficients during monsoon season are found to be 0.37 and 0.55 in dense (Arnigad) and degraded (Bansigad) micro-watersheds respectively.
- Mean annual runoff-coefficients, estimated in dense and degraded forested micro-watersheds, are 0.56 and 0.64 respectively.
- Average denudation rates are found to be 0.59 mm in dense forested micro-watershed and 1.05 mm in degraded micro-watershed respectively.
- Isotopic characterization of stream, rain and spring water has been completed. Results will be presented in the meeting.
- SWAT model was calibrated and validated on Arnigad and Bansigad watersheds using the observed daily data of discharge and sediment concentration. The results of simulation of Arnigad watershed exhibited the coefficient of determination (r^2) and Nash-Sutcliff efficiency as 0.91 and 84.48% for daily flows and 0.88 and 83.11% respectively for daily sediment concentration during calibration; and r^2 and efficiency as 0.94 and 82.78% for daily flows and 0.88 and 83.28% respectively for daily sediment concentration during validation.



Rainfall-Runoff of both watersheds



Variation of Suspended sediment load with rainfall

13 **Adopters of the results of the study and their feedback** : R & D organizations, state forest departments, also watershed conservation and management

agencies

14 **List of deliverables** : Papers

15 **Major items of equipment procured** : NIL

16 **Lab facilities used during the study** : Isotope and Hydrological Instrumentation Laboratory

17 **Data procured and/or generated during the study** : Hydro-meteorological data and isotopic data generated for both the watersheds

18 **Study Benefits / Impact** :

Activity	Status
Selection of two watersheds under different forest covers	Completed
Instrumentation in both the watersheds	Completed
Identification of springs and handpumps	Completed
Geomorphological details	Completed
Geological details	Completed
Infiltration tests	Completed
Collection of SW and GW samples for water isotopic analysis	Completed
Collection of sediment data	Completed
Analysis of stable isotopes (δD and $\delta^{18}O$) of SW and GW samples	Completed
Assessment of impact of forest cover on stream discharge	Completed
Assessment of impact of forest cover on erosion	Completed
Estimation of sediment erosion using the SWAT model	Completed

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

20 **Shortcomings/difficulties, if any** : NIL

21 **Future plan** : Preparation of papers from the reports

Annexure – 9

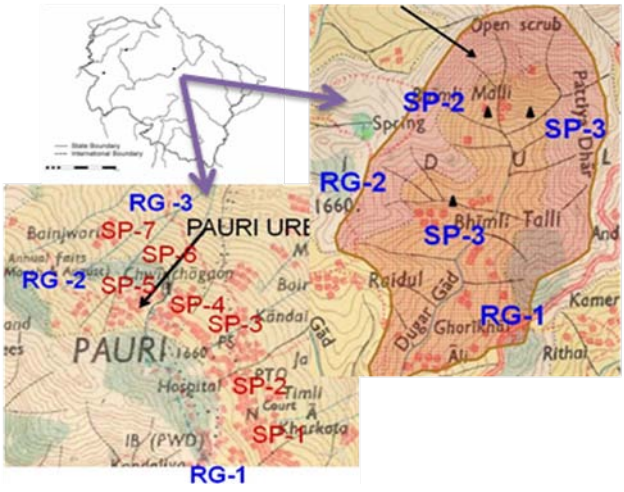
ACTIVITY SCHEDULE FOR IMPACT ASSESSMENT OF LANDUSE ON THE HYDROLOGIC REGIME IN THE SELECTED MICRO-WATERSHEDS IN LESSER HIMALAYAS, UTTARAKHAND (QUARTER WISE: 2011-12 AND 2012-2013)

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th
Collection of discharge data with the help of FRI	♦	♦	♦	♦	♦			
Collection of meteorological data with the help of FRI	♦	♦	♦	♦	♦			

Identification of data gaps	♦							
Collection of water samples for isotopic (δD and $\delta^{18}O$) analysis	♦	♦	♦	♦				
Measurement of δD and $\delta^{18}O$	♦	♦	♦	♦	♦	♦		
Rainfall runoff analysis on monthly basis		♦	♦	♦				
Hydrograph separation using the isotope data			♦	♦	♦	♦		
Establishment of altitude effect		♦	♦	♦				
Identification of recharge zones of springs and streams				♦	♦	♦		
Estimation of natural recharge to groundwater		♦	♦					
Creation of GIS data base for SWAT		♦	♦					
Analysis of data using SWAT			♦	♦				
Development of conceptual model				♦	♦			
Calibration of model					♦	♦		
First Draft Report						♦		
Second Draft Report							♦	
Final Report								♦

10. REFERENCE NUMBER: NIH/HID/GBPIHED/2010-13

1	**Title of the study**	:	**DEVELOPMENT OF SPRING SANCTUARIES IN AN URBAN AND A RURAL WATERSHED IN DISTRICT PAURI GARHWAL, UTTARAKHAND**
2	**Name of PI, Co-PI, & their affiliations**	:	Dr. S. P. Rai (PI) Dr. Sudhir Kumar Dr. S. D. Khobragade Mr. P. K. Garg Dr. S. Tarafdar, GBPIHED Mr. Jamil Ahmad Mr. Vishal Gupta
3	**Type of study**	:	Internal
4	**Date of start, scheduled date of completion**	:	April 2010 to March 2013
5	**Location map**		



Study Area	
Pauri Town	Dugar Watershed
Urban Area	Rural Area
No. of springs selected = 7	No. of springs selected = 3

6	**Study objectives**	:	● To decipher the recharge zone of springs falling in the study area ● To analyze the relationship between rainfall, evaporation, landuse/land cover and ecological factors with spring discharge (GBPIHED,

Srinagar)

● Formulation of strategies to implement spring sanctuary strategy in the identified recharge area in order to enhance the discharge

7 **Statement of the problem** : Groundwater flows in the form of springs and seepages in the hilly terrain. Springs are the major source of drinking and other household activities in the hilly terrain. The dwindling discharges of springs and spring fed streams in the populated Lesser Himalayan terrain of Western Himalayas has become a matter of serious concern. In this connection, Jal Sansthan, Uttarakhand has approached NIH for identification of recharge zone. GBPIHED, Srinagar Unit has approached NIH for collaborative study of recharge zone identification and implementation of recharge techniques. The fundamental question related to springs are:

- ❖ Where does water originate?
- ❖ How fast is the water moving?
- ❖ How much water is flowing?
- ❖ Is discharge declining?
- ❖ How we can rejuvenate drying springs?

8 **Approved action plan** : Please see Annexure 10

9 **Timeline and justification for time over runs** : March 2013

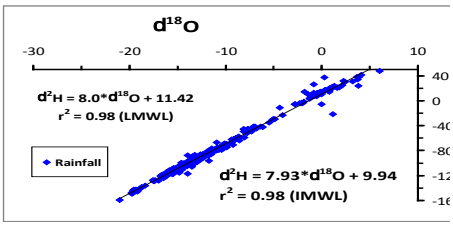
10 **2-column table showing objectives vis-à-vis achievements** :

Objectives	Achievements
To decipher the recharge zone of springs falling in the study area	Hydrogeological map has been prepared.
To analyze the relationship between rainfall, evaporation, landuse/land cover and ecological factors with spring discharge	Rainfall and other data collected.
To implement spring sanctuary strategy in the identified recharge area in order to enhance the discharge	Interpretation of results under progress for identification of recharge zones.

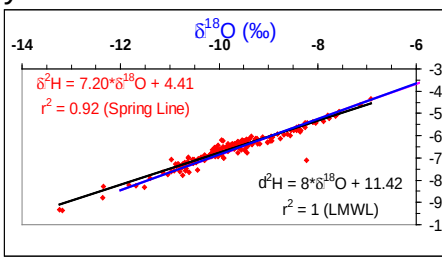
11 **Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken** : NIL

12 **Analysis and Results** :

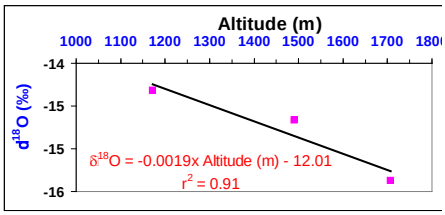
- The plot of δ^2H versus $\delta^{18}O$ for rainfall samples collected during June to September 2010 shows the Meteoric Water Line (spring) as $\delta^2H = 8.0 \times \delta^{18}O + 11.4$ which is similar to IMWL .
- The plot of δ^2H versus $\delta^{18}O$ for all springs samples collected during June to September 2010 shows the Meteoric Water Line (spring) as $\delta^2H = 7.20 \times \delta^{18}O + 4.41$ which is very close to LMWL
- Temporal variation of isotopic data of springs of Dugargad watershed shows depletion after July and maximum depletion is in the month of September. It indicates quick response of recharge in the springs.
- Similarly, springs samples collected from Pauri city show depletion after July and maximum depletion is in the month of September.
- These results indicate that source of these springs are local precipitation.
- Altitude effect is developed and determination of recharge zones of springs is under progress.
- The details of the study will be presented in the working group meeting.



Isotopic composition of rainfall in study area



δ^2H versus $\delta^{18}O$ of springs and rainfall of the study area



Altitude effect in the area

13 **Adopters of the results of the study and their feedback** : Jal Sansthan, Uttarakhand

14 **List of deliverables** : Report and papers

15 **Major items of equipment procured** : NIL

16 **Lab facilities used during the study** : Isotope and Hydrological Instrumentation Laboratory

17 **Data procured and/or generated during the study** : Isotopic data of the springs and rainfall of study area

18 **Study Benefits / Impact** :

Activity	Status
Selection of sampling site	Completed
Sample collection started since June 2010	Continued
Analysis of stable isotopes (δD and $\delta^{18}O$) of collected samples	Continued
Compilation of the results	In progress

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

20 Shortcomings/difficulties, if any : NIL

21 Future plan : To implement the finding in the study area

Annexure- 10

ACTIVITY SCHEDULE FOR DEVELOPMENT OF SPRING SANCTUARIES IN AN URBAN AND A RURAL WATERSHED IN DISTRICT PAURI GARHWAL, UTTARAKHAND (QUARTER WISE: 2011-12 AND 2012-2013)

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th
Collection of spring, rainfall and stream samples for isotopic (δD and $\delta^{18}O$) analysis with the help of GBPIHED, Srinagar unit	♦	♦	♦	♦	♦	♦		
Measurement of δD and $\delta^{18}O$ in laboratory	♦	♦	♦	♦	♦	♦	♦	
Development of meteoric water line for spring, rainfall etc			♦	♦		♦	♦	
Establishment altitude effect				♦	♦			
Analysis of discharge data of spring and its relationship with isotope data			♦	♦		♦	♦	
Estimation of recharge zones of spring					♦	♦		
Formulation of strategies for development of spring sanctuaries						♦	♦	
First Draft Report						♦		
Second Draft Report							♦	
Final Report								♦

11. REFERENCE NUMBER: NIH/HID/IAEA/2012-13

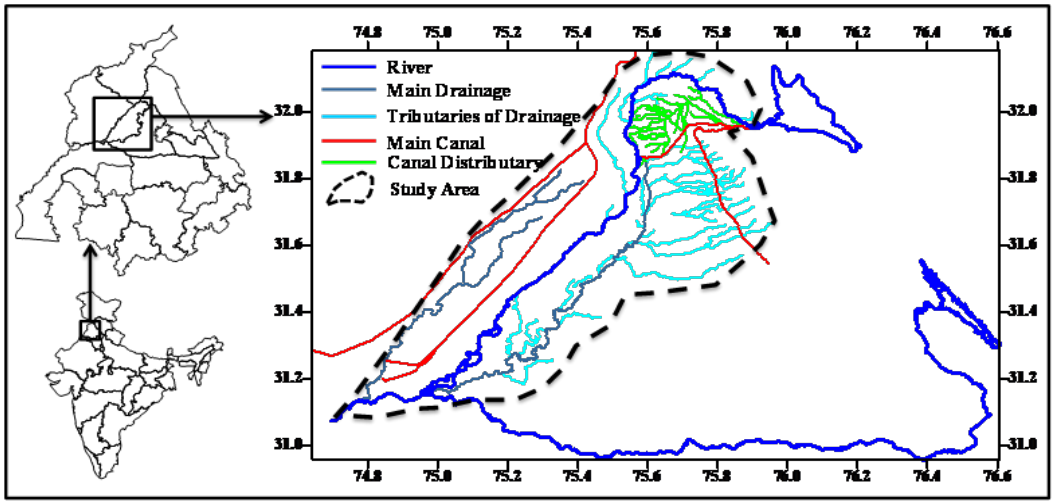
Title of the study : **THE USE OF ENVIRONMENTAL ISOTOPES TO ASSESS SUSTAINABILITY OF INTENSIVELY EXPLOITED AQUIFER SYSTEMS IN NORTH EASTERN PARTS OF PUNJAB, INDIA**

Name of PI and members: Dr. M. S. Rao (PI)
Mr. C. P. Kumar
Dr. S. P. Rai

Type of study: Sponsored by IAEA, Vienna

Date of start, **Scheduled date of completion:** September 2012, August 2013

Location map:



Study objectives:

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

Statement of the problem:

As per report of CGWB, 80% area of Punjab falls under over-exploited zone. The concentrated pumping 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 isotope 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 being developed for irrigation and drinking needs have been entering into the deeper aquifers. The Doab region is underlain by hundreds of meters thick alluvium and detailed study of groundwater age of deeper aquifer is yet to be mapped using ^{14}C dating. The present study is intended to assess the mid and long term sustainability of groundwater resources, especially in aquifers that have been providing large quantities of water over the last decades. The study region will be an extended part of Bist Doab region where groundwater is getting over-exploited.

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

Methodology:

In this study, groundwater samples will be collected from the deeper aquifers (piezometers and groundwater wells) and will be analysed for water quality through Ion Chromatograph, and for stable isotopes. The groundwater dating investigations will be done to determine the age of water. On the basis of interpretation of results, suitable management measures will be suggested to improve the groundwater conditions in the study area.

In the present program, in addition to the stable H/O isotopes, ^{3}H, ^{14}C and $^{13}C/^{12}C$ isotopes, other tracers such as $^{3}H/^{3}He$ and noble gases will also be used with the support of IAEA. As a result, the exercise will also bring this new technology ($^{3}H/^{3}He$, noble gas technique) to the institute. As a standard method, major/trace ion chemistry, historical and current groundwater level, salinity/water quality will also be measured/analyzed.

Action plan:

Year	**April 2013 to August 2013** (Annexure 11)	**Remark**
Apr. 2013 to Aug. 2013	Review and synthesis of the groundwater data, isotope data and hydro-chemical data Water sampling, analysis and data interpretation Report writing	Report preparation as per Annexure 11

Work and Progress

One international review of the CRP has been held at IAEA, Vienna during 5-7 Nov. 2012, where 14 countries participating in CRP presented the outlook of the project. The methodology of the CRP has been well defined by modifying proposed timelines and international collaboration with IAEA. In the meeting, the role of NIH has been defined as in addition to stable isotopes of Oxygen and Hydrogen, Tritium and Carbon-14 (mainly for dating deep aquifers/ old water samples where tritium content is negligible) and ^{13}C (for radio carbon age modeling). The analysis for $^{3}H/^{3}He$ and

noble gases will be carried out at IAEA, Vienna. According to the approved time line, presently revision of available hydrological and isotope information is in progress. The sampling of water samples in the study area will be carried out during the first quarter of 2013 (during pre-monsoon of 2013).

Study Benefits /Impact:

- ❑ Improved understanding of groundwater dynamics in shallow and deep aquifers
- ❑ Thematic maps of spatial distribution of isotopic, hydrogeological and quality aspects of groundwater
- ❑ Research publications and report

Data requirement & Expected source:

From the previous study carried out during 2010-2012, data for shallow (<15 m) and deep groundwater (>30m) for stable isotopic analysis, tritium dates, water quality and change in depth to water table in Bist- Doab region (western parts of study area) of Punjab are available.

IPR potential and issues: NIL

Major items of equipment needed: None

Specific linkages with Institutions: IAEA, Vienna

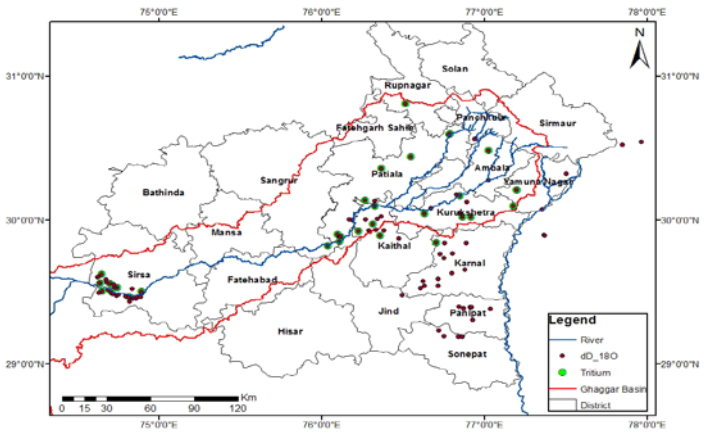
Annexure - 11

ACTIVITY SCHEDULE FOR THE USE OF ENVIRONMENTAL ISOTOPES TO ASSESS SUSTAINABILITY OF INTENSIVELY EXPLOITED AQUIFER SYSTEMS IN NORTH EASTERN PARTS OF PUNJAB, INDIA (QUARTER WISE: APRIL 2013 TO AUGUST 2013)

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

12. REFERENCE NUMBER: NIH/HID/MOES/2012-15

1	**Title of the study**	:	**THE STRUCTURE AND DYNAMICS OF GROUNDWATER SYSTEMS IN NORTHWESTERN INDIA UNDER PAST, PRESENT AND FUTURE CLIMATES**
2	**Name of PI, Co-PI, & their affiliations**	:	Dr. S. P. Rai (PI) Dr. M. S. Rao Dr. Surjeet Singh Mr. S. K. Verma Mr. C. P. Kumar Dr. Sudhir Kumar Mr. V. K. Agarwal Mr. Rajeev Gupta Mr. S. L. Srivastava Mr. Vishal Gupta Mr. Mohar Singh
3	**Type of study (sponsored/ consultancy/ referred/ internal). If referred, mention the reference**	:	Sponsored
4	**Date of start, scheduled date of completion**	:	June 2012 to March 2015
5	**Location map (wherever applicable)**		



Study Area	
Northwestern India	Catchment of Ghaghar Basin covering parts of Haryana, Punjab and Rajasthan
Landuse	Agriculture dominated
Geology	Alluvial plain
Major problem	Groundwater declining very fast

6	Study objectives	:	(a) Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water (b) Groundwater dating using Tritium and Carbon-14

(c) Measurement of Radon in groundwater
(d) Delineation of flow direction and recharge zones
(e) Identification of recharge source and zones of groundwater in the study area

7 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 results of this, groundwater depletion of this region is under the vulnerable condition and become a hotspot for groundwater management. The groundwater depletion rates in 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.

8 **Approved action plan** **:** Please see Annexure 12

9 **Timeline and justification for time over runs** **:** Time line is as per Annexure 12. No time overruns so far.

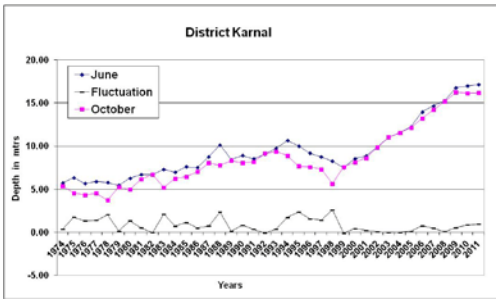
10 **2-column table showing objectives vis-à-vis achievements** **:**

Objectives	Achievement
• Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water • Groundwater dating using Tritium and Carbon-14 • To decipher the recharge zone of springs falling in the study area • Measurement of Radon in groundwater • Delineation of flow direction and recharge zones • To study the impact of climate change on groundwater recharge • Identification of recharge source and zones of groundwater in the study area	Field survey conducted and samples of groundwater and river collected.

11 Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken : NIL

12 **Analysis and Results** :

- The groundwater level data of Haryana and Punjab have been collected to study the groundwater level trend.
- The groundwater, canal and river samples have been collected for stable isotope and chemical and isotopic analysis.
- Details of the study will be presented in the working group meeting.



13 Adopters of the results of the study and their feedback : Punjab and Haryana State Ground Water Department

14 List of deliverables : Reports and papers

15 Major items of equipment procured : NIL

16 Lab facilities used during the study : Isotope and Hydrological Instrumentation Laboratory

17 Data procured and/or generated during the study : Isotopic data of the groundwater

18 Study Benefits / Impact :

Activity	Status
Selection of sampling site	Continued
Sample collection (started since Aug 2010)	Continued
Analysis of stable isotopes (δD and $\delta^{18}O$) and Tritium of collected samples	Continued
Compilation of the results	In progress

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

20 **Shortcomings/difficulties, if any** : NIL

21 **Future plan** : To implement the finding in the study area

Annexure – 12

ACTIVITY SCHEDULE FOR THE STRUCTURE AND DYNAMICS OF GROUNDWATER SYSTEMS IN NORTHWESTERN INDIA UNDER PAST, PRESENT AND FUTURE CLIMATES

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Selection of study area	♦											

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

NEW STUDIES (AFTER LAST WORKING GROUP MEETING)

1. REFERENCE NUMBER: 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**

Name of PI and members: Dr. M. S. Rao (PI)
Mr. C. P. Kumar
Dr. Gopal Krishan

Type of study: Sponsored by BGS, UK under DFID

Date of start, **Scheduled date of completion:** February 2013 to May 2014

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

Study objectives:

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

Statement of the problem:

The Indo-Gangetic plain supports one of the most populous areas on the earth. It is home to approximately 1 billion people. The economy, poverty and health of the region are highly diverse and include areas of extreme poverty as well as highly successful and growing economies. Exploiting easily accessible water resources for drinking water, agriculture and growing industries has been fundamental to the region's success and will continue to play a large part in its future. Despite the presence of large rivers, groundwater is highly exploited across the basin.

Within the Indo-Gangetic Basin, groundwater condition has reached to most critical condition in Punjab. As per the assessment of the Central Groundwater Board (2009), the stage of Groundwater Development of the state is 170 % leaving little scope for further development of dynamic resource except few pockets. The gravity of the situation can be gauged from the fact that stage of groundwater utilization exceeded 300% in some parts of the northeast Punjab. Considering these facts, it is proposed to prepare a report on groundwater availability in the Indo-Gangetic Basin and to examine the case in detail across heavily exploited region of Punjab.

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

Methodology:

In this study, groundwater samples will be collected from the deeper and shallow aquifers (piezometers and groundwater wells) and will be analysed for stable isotopes ($\delta^{18}O$ and δD), groundwater dating using CFC & SF_6 (at BGS, UK) and also for water quality through Ion Chromatograph. Using this, groundwater recharge areas, recharge rates, recharging water temperature and flow conditions will be examined.

Action plan:

Year	**February 2013 to May 2014** (Annexure 13)	**Remark**
Feb. 2013 to May 2014	Literature review on available groundwater studies including water table, water quality and other hydrogeological aspects falling within the Indian portion of IGB Prepare a status report on groundwater issues in IGB (only for the Indian portion) Presentation of work progress in a workshop/review meeting under the project Field sampling of a transect using isotopes and residence time indicators in conjunction with specialist team from BGS to investigate resilience of groundwater in Punjab to withdrawal and environmental change Fabrication of sampling units for groundwater collection for CFC, SF_6 and noble gas analysis	Report preparation as per Annexure 13

Study Benefits /Impact:

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

Specific linkages with Institutions: BGS, UK

Annexure - 13

ACTIVITY SCHEDULE FOR REVIEW OF GROUNDWATER RESOURCES IN THE INDO-GANGETIC BASIN: A CASE STUDY ON RESILIENCE OF GROUNDWATER IN THE PUNJAB TO WITHDRAWAL AND ENVIRONMENTAL CHANGE (QUARTER WISE: FEBRUARY 2013 TO MAY 2014)

Activity	**1st (Feb-Apr 2013)**	**2nd (May-Jul 2013)**	**3rd (Aug-Oct 2013)**	**4th (Nov-Jan, 2013-14)**	**5th (Feb-Apr 2014)**
Sampling	♦	♦	♦	♦	♦
Collection of data from various agencies (NIH)	♦	♦	♦	♦	♦
Recharge studies in unsaturated zone including sampling and analysis		♦	♦	♦	♦
Analysis of isotopic & CFC, SF6, noble gases (NIH-BGS)	♦	♦	♦	♦	
Water quality analysis of samples (NIH-BGS)	♦	♦	♦	♦	
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

2. REFERENCE NUMBER: NIH/HID/IAEA/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 Group:
Dr. S. P. Rai (PI)
Dr. R. V. Kale
Dr. M. S. Rao
Mr. C. P. Kumar
Dr. Sudhir Kumar
Mr. V. K. Agarwal
Mr. Vishal Gupta
Mr. Mohar Singh

Type of Study: Sponsored by IAEA, Vienna.

Nature of Study Application of isotope and conceptual model to assess baseflow contribution in the river runoff and water quality characteristics

Duration: 3 years

Date of Start: October 2012

Date of Completion: September 2015

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 the River Satluj in Indian context is better understood from the fact that it continues to play a major role in the socio-economic development of the 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 river Satluj 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 has been overlooked and no major attempts have 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.

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

Study Area: Study area covers the parts of the Satluj river basin in Punjab State, India

Methodology:

- Field investigations in the study area
- Hydrogeological investigations of the study area using past data of CGWB and state groundwater cell
- Stable isotopic analysis of rain, river and groundwater
- Tritim and Carbon-14 dating to determine the age of groundwater
- Delineation of drainage and preparation DEM using remote sensing and GIS
- Application of conceptual models
- Analysis of the results

Action plan & time line: Please see Annexure 14

Data requirement & Expected source:

Meteorological data (i.e., rainfall, maximum & minimum temperature, sunshine hours, relative humidity, solar radiation etc), water level data and hydrogeological data are required. Meteorological data would be purchased from IMD. The water level and geological information will be collected from CGWB and state groundwater cell. Soil data would be collected from agriculture department.

List of deliverables:

Assessment of baseflow contribution in river Satluj and its impact on water quality
Development of isotope technique to study the baseflow
Application of conceptual models

IPR potential and issues: NIL

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

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

Major items of equipment needed: None

Annexure - 14

ACTIVITY SCHEDULE FOR ASSESSMENT OF BASEFLOW AND ITS IMPACT ON WATER QUALITY IN THE PART OF SATLUJ RIVER IN INDIA USING ENVIRONMENTAL ISOTOPES AND AGE DATING TECHNIQUES (QUARTER WISE: 2012-13, 2013-2014 AND 2014-2015)

Activity	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**
Selection of study area			♦									
Literature survey			♦	♦	♦							
Collection of previous years data				♦	♦							
Identification of data gaps				♦								
Selection of sites for stable isotope (δ^2H and $\delta^{18}O$) analysis					♦	♦	♦	♦				
Selection of sites for radio-isotope (^3H and ^{14}C) analysis			♦	♦	♦	♦	♦	♦	♦	♦		
Site selection and Installation of raingauges			♦	♦	♦	♦						
Measurement of δ^2H and $\delta^{18}O$ of rain. river and groundwater				♦	♦	♦	♦	♦	♦	♦		
Measurement of ^3H and ^{14}C activity of groundwater, rain and river				♦	♦	♦	♦	♦	♦	♦		
Measurement of radon in groundwater								♦	♦	♦		
Preparation of geological and hydrogeological maps of the study area				♦	♦	♦	♦	♦				
Preparation of water table and flow direction map on the basis of previous years data				♦	♦	♦						
Interpretation of isotopic data					♦	♦	♦	♦	♦	♦	♦	
Application of conceptual model					♦	♦	♦	♦	♦	♦	♦	
Estimation of baseflow and river water quality									♦	♦	♦	
First Draft Report										♦		
Second Draft Report											♦	
Final Report												♦

3. REFERENCE NUMBER: NIH/HID/INT/2013-15

Title of the study: **WATER AVAILABILITY STUDIES FOR SUKHNA LAKE, CHANDIGARH**

Name of PI and members: Dr. S. D. Khobragade (PI)
Mr. C. P. Kumar
Dr. Sudhir Kumar
Dr. A. R. Senthil Kumar
Mr. P. K. Garg
Mr. V. K. Agarwal

Type of study: Internally Funded

Date of start, **Scheduled date of completion:** April 2013 to March 2015

Location: Sukhna Lake, Chandigarh

Study objectives:

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

Statement of the problem:

Sukhna lake in Chandigarh is a popular destination for recreation and tourism. However, the lake is in limelight in recent years due to various problems being faced by it. One of the serious problems of the lake is declining water availability in recent years. Water availability analysis has already been carried out based on limited available data, under a consultancy project on the lake carried out by NIH. However, aspects such as seepage losses from the lake, inflow regime of the lake, lake water levels-rainfall relations, rainfall-runoff relations for lake catchment etc. are needed to be further investigated in detail using additional and long term data. The study is therefore being proposed as Phase-II of the investigation being carried out on Sukhna Lake by the Institute.

Whether Study is a New Study/Extension of Previous Studies: Extension of the work carried out in a previous study for more detailed analysis.

Methodology:

Discharge and other hydro-meteorological data, water level data for lake and open wells, etc. would be generated in the field. Systematic water balance of the lake would be carried out. Evaporation would be determined using Penman Method. Trend analysis of rainfall and evaporation would be carried out using standard

statistical tests. Long term data of rainfall and evaporation would be purchased and analyzed. Seepage analysis would be carried out using water table data and isotope analysis. Water samples would be collected for isotopic analysis. Water availability analysis of the lake would be carried out based on the basis of systematic assessment of water balance of the lake.

Action plan: Please see Annexure 15

Study Benefits /Impact:

The results of the study would help in better understanding of the hydrological behaviour of the lake and therefore, would help in suggesting specific measures for improving water availability in the lake.

Specific linkages with Institutions: Chandigarh Administration, Chandigarh and IPRI, Amritsar

Data requirement & Expected source:

Data previously collected during the consultancy project on Sukhna lake would be used as base data. Further hydro-meteorological data will be generated in field. Long term data on pan evaporation and rainfall would be purchased from Central Soil and Water Conservation and Research Institute, Chandigarh.

IPR potential and issues: NIL

Major items of equipment needed: DGPS, AWLR, ARG, Pocket weather station etc.

Annexure-15

ACTIVITY SCHEDULE FOR WATER AVAILABILITY STUDIES FOR SUKHNA LAKE, CHANDIGARH (QUARTERWISE: APRIL 2013 TO MARCH 2015)

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

4. REFERENCE NUMBER: NIH/HID/IAEA/2013-15

Title of the study: **ISOTOPE STUDIES FOR THE IDENTIFICATION OF DIFFERENT AQUIFER GROUPS AND THEIR DYNAMICS IN UPPER YAMUNA RIVER PLAINS**

Name of PI and members: Dr. Sudhir Kumar (PI)
Dr. C. K. Jain
Dr. S. P. Rai
Dr. S. D. Khobragade
Mr. P. K. Garg
Two Officers from CGWB

Type of study: Likely to be sponsored by IAEA, Vienna

Date of start, **Scheduled date of completion:** July 2013 - June 2015

Location map:

Study objectives:

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

Statement of the problem:

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

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

the institutional arrangements for management.

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

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

Methodology:

Firstly aquifer geometry in the study area will be developed using the data available with Central Ground Water Board, Government of India, Uttar Pradesh Ground Water Department and Department of Minor Irrigation, Haryana. Water samples from existing wells tapping different aquifers, canals and rivers traversing the area and precipitation shall be collected for the stable isotope analysis and ^{3}H dating. The analysis of the environmental isotopes $\delta^{18}O$, δD and ^{3}H shall be carried out in the Stable Isotope Laboratory and Groundwater Dating Laboratory of the National Institute of Hydrology. Geochemical analysis of the water samples shall be carried out using Ion chromatograph and Atomic Absorption Spectrometer in the Water Quality Laboratory of the Institute. If ^{3}H is not detected in the groundwater samples, then samples for ^{3}H-He dating will be collected. The instruments for collection of He shall be borrowed from IAEA and the ^{3}H-He dating will be performed at IAEA. If the age of groundwater could not be determined by either ^{3}H or ^{3}H-He method then samples for ^{14}C dating will be collected from different aquifers and got analyzed using Acceleration Mass Spectrometer (AMS) in Europe through a recognized laboratory through IAEA. Groundwater flow direction in the deeper aquifers shall be ascertained by measuring the age of groundwater. Younger ages will indicate the modern recharge zones whereas the older ages will indicate groundwater discharge zones/residence time in aquifer.

Thus, the isotopic characterization of groundwater from different aquifers shall give an idea about the interaction and groundwater flow direction. Further geochemical and isotope groundwater modeling shall give an idea about mixing of different water in the aquifers.

Action plan: Please see Annexure 16

Study Benefits /Impact:

The results of this research project shall contribute to better understanding of the aquifer systems in alluvial plains of vast Indo-Gangetic plains and particularly to the Upper Yamuna plains in India. The recharge zones to the deeper aquifers, interaction between different aquifers and the groundwater dynamics are expected to be better understood using isotopic techniques rather than the conventional hydrogeological methods. The results of the study will demonstrate the application of isotopes in identification and refinement of aquifer mapping project initiated by the Government of India.

Specific linkages with Institutions: Central Ground Water Board and International Atomic Energy Agency

Data requirement & Expected source:

All hydrogeological data will be collected from the Central Ground Water Board under a MoU.

IPR potential and issues: NIL

Major items of equipment needed: None

Annexure-16

ACTIVITY SCHEDULE FOR ISOTOPE STUDIES FOR THE IDENTIFICATION OF DIFFERENT AQUIFER GROUPS AND THEIR DYNAMICS IN UPPER YAMUNA RIVER PLAINS

Activity	2013		2014				2015	
	3rd	4th	1st	2nd	3rd	4th	1st	2nd
Collection of available literature and data from CGWB and State Groundwater Departments	*							
Identification of wells for groundwater sampling	*							
Construction of aquifer geometry based on available data / information		*						
Collection of groundwater and river /canal/rainfall samples for chemical and stable isotope analysis		*	*		*			
Chemical and stable isotopic analysis of samples		*	*		*	*		
Tritium samples analysis and dating		*	*	*	*	*		
Collection of samples for ^{3}H-He dating					*			
^{3}H-He sample analysis at IAEA					*	*		
Collection of samples for ^{14}C dating		*	*		*			
^{14}C samples analysis at IAEA designated laboratory			*	*	*	*		
Interpretation of data			*	*	*	*	*	
Interim Report and discussion of results during the meeting to be hosted by IAEA				*				
Workshop				*			*	
Final draft report and discussion on outcome during the meeting to be hosted by IAEA + final report submission								*

SURFACE WATER HYDROLOGY DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2012-13

S. No. & Ref. Code	Title	Study Team	Duration
Internal Studies			
1. NIH/SWD/NIH/10-13	Snowmelt Runoff Modeling and Study of the Impact of Climate Change in part of Brahmaputra River Basin	Archana Sarkar R.D. Singh Rakesh Kumar Sanjay K. Jain	3 years (April 10-March 13)
2. NIH/SWD/NIH/11-13	Impact of Climate Change on Glaciers and Glacial Lakes: Case Study on GLOF in Tista basin	A.K. Lohani Sanjay K. Jain Rakesh Kumar	2 years (April 11 – March13)
3. NIH/SWD/NIH/10-13	Climatic Scenarios Generation for Satluj Basin using Statistical Downscaling Techniques	Manohar Arora Rakesh Kumar	3 years (April 10 – March 13)
4. NIH/SWD/NIH/10-13	Climatic variability analysis and its impact on Himalayan watershed in Uttarakhand	A. Agarwal, Manohar Arora R K Nema	3 years (Nov. 10 – Oct. 13)
5. NIH/SWD/NIH/08-	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	March 08 - To be continued
6. NIH/SWD/NIH/11-14	Hydrological Studies for Upper Narmada Basin.	Jagdish P. Patra Rakesh Kumar Pankaj Mani T R Sapra	3 years (April 11 – March 14)
7. NIH/SWD/NIH/12-15	Study of Hydro-Meteorological Droughts for Bundelkhand Region in India	R.P. Pandey	3 years (April 12-March 15)
8. NIH/SWD/NIH/12-15	Sedimentation Studies for Pong Reservoir, Himachal Pradesh	A. R. S. Kumar, Manohar Arora Suhas D Khobragade, A. Agarwal, Sanjay K. Jain	3 years (April 12 – March 15)

WORK PROGRAMME FOR THE YEAR 2013-14

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

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

a) Title of study: **Snowmelt Runoff Modeling and Study of the Impact of Climate Change in part of Brahmaputra River Basin**

b) Study group: Archana Sarkar (PI), Sc 'C', SWH Div.
R.D. Singh, Director
Rakesh Kumar, Head & Sc. 'F', SWH Div.
Sanjay K. Jain, Sc. 'F', WRS Div.

c) Type of study: Internal

d) Date of start: April 1, 2010

e) Scheduled date of completion: March 31, 2013

f) Study Area:

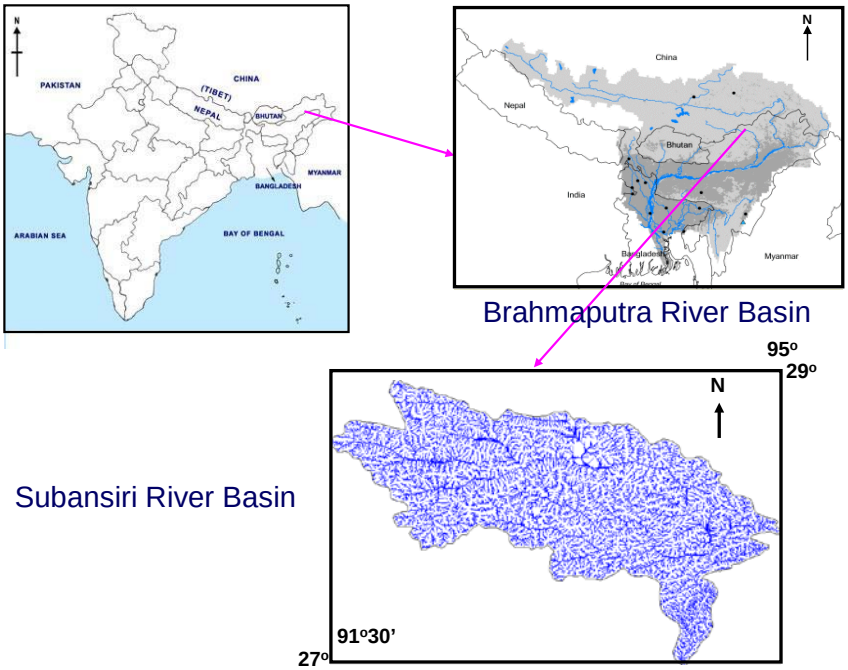


Fig. 1: Study Area

g) Objectives of the study:

1. To estimate snow cover area using remote sensing data
2. To estimate snow melt runoff in Subansiri River basin at Choulduaghat site.
3. To study trend of precipitation and temperature using parametric and non parametric approaches, and
4. To investigate the impact of likely future changes in climate on stream flow using precipitation and temperature scenarios in the study area.

h) Statement of the problem:

Prime Minister's Council on Climate Change, in its first meeting decided that MoWR should initiate studies for major rivers whose waters come from snow melt. Accordingly, MoWR chalked out an Action Plan to take up related studies on Indus, Ganges and Brahmaputra River basins through CWC, NIH and Brahmaputra Board. The present study has been taken up with this background.

i) Approved action plan:

Activities	I Year	II Year	III Year
To estimate snow cover area and its temporal variation in study basin	↔		
Preparation of a technical report on "Snow Cover estimation and its temporal variation in a part of Brahmaputra River basin"	↔		
To estimate stream flow (including snowmelt runoff) in Subansiri River at Choulduaghat site through calibration and validation of hydrological model.		↔	
To simulate stream flow for the study basin in present climatic conditions using long term records		↔	
Preparation of a technical report on "Snowmelt Runoff Modelling in a part of Brahmaputra River basin"		↔	
To study trend of precipitation and temperature using parametric and non parametric approaches			↔
To simulate stream flow for the basin considering various scenarios of climate (temperature and precipitation) variables and evaluate the impact of changes in climatic variables on stream flow			↔
Compilation of results and preparation of final technical report			↔

j) Role and Responsibility of Team Members:

Team Member	**Role and Responsibility**
Archana Sarkar, Scientist C (PI)	Overall responsibility: Procurement of Data, analyzing data/information, calibration & Validation of SNOWMOD program, statistical trend analysis and report writing
R.D. Singh, Director	Advisory: Data analysis and results interpretations
Rakesh Kumar, Scientist F & Head	Advisory: Data procurement, data processing and statistical data analysis
Sanjay K. Jain, Scientist F	Advisory: Snow Cover data analysis, calibration & validation of SNOWMOD program and results interpretations

k) Progress:

Objectives	Achievements
April 2010- March 2011	
1. To estimate snow cover area and its temporal variation in study basin 2. Preparation of interim technical report on "Snow Cover estimation and its temporal variation in Subansiri River basin".	Completed Completed
April 2011- March 2012	
1. To simulate stream flow for the study basin in present climatic conditions using SNOWMOD **2.** Preparation of interim technical report on "Snowmelt Runoff Modelling in a part of Brahmaputra River basin"	Completed Completed
April 2012 – Oct. 2012	
1. Study of trend of precipitation and temperature using parametric (regression) and non parametric (Man-Kendall) approaches	Completed
Oct. 2012-March 2013	
1. Study of the impact of climate change scenarios of runoff of the study basin 2. Preparation of Final Report	Completed In progress

l) Recommendations/suggestions in previous meetings of Working Group/TAC/GB: Nil

m) Analysis and Results:

Data Used

- Daily data of rainfall, temperature, snowcover area and discharge.

Results

The probable impact of climate change has been analyzed using hypothetical climate scenarios to understand the behavior of snowmelt runoff and total streamflow of Subansiri basin under the changed climatic conditions. Ten hypothetical scenarios, viz (T + 1°C, P + 0%), (T + 2°C, P + 0%), (T + 1°C, P + 5%), (T + 2°C, P + 5%), (T + 1°C, P + 10%), (T + 2°C, P + 10%), (T + 1°C, P - 5%), (T + 2°C, P - 5%), (T + 1°C, P - 10%), (T + 2°C, P - 10%) with respect to the baseline scenario (T + 0, P + 0%) have been created. The climate change impact study has been carried out with data of 2000-2003 and 2004-2007. It has been observed that total stream flow as well as snowmelt runoff increases when temperature is increased. The reason behind this increase is the increased snowmelt runoff which increases because of more melting of snow with the rise in temperature. The observed increase in snowmelt runoff for increase of 1°C and 2°C in temperature is about 2.5% and 5% respectively. However, there is not much change in snowmelt runoff with the changed precipitation scenarios. This study points towards change in total stream flow of Subansiri basin for all the scenarios of temperature and precipitation. The observed maximum % increase in mean annual stream flow is about 5% for

(T+2°C & P+10%) scenario and the maximum decline in mean annual stream flow observed is about 11% for (T+1°C & P-10%) scenario. Figures 2 & 3 show the change in the mean annual discharge and mean annual snowmelt runoff respectively for the Subansiri basin under various climate scenarios.

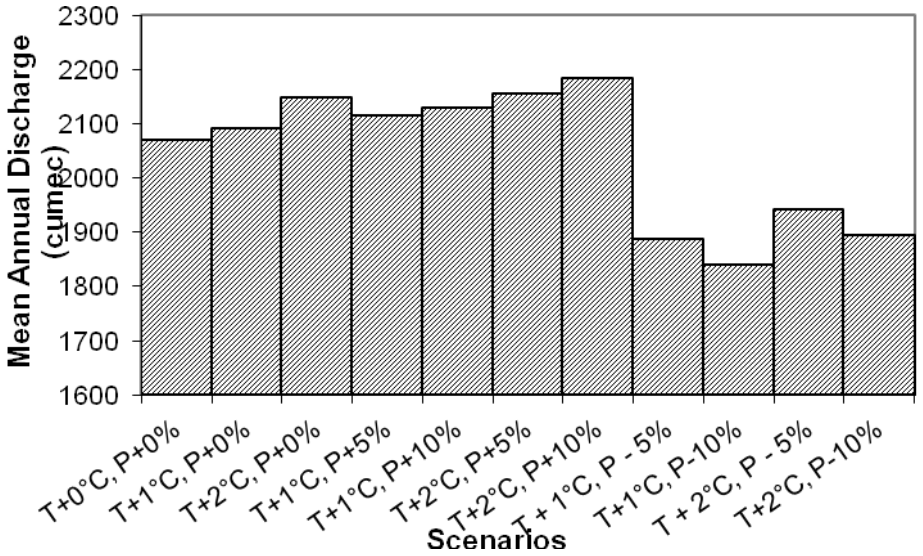


Fig. 2: Mean annual streamflow for various climate scenarios in Subansiri basin

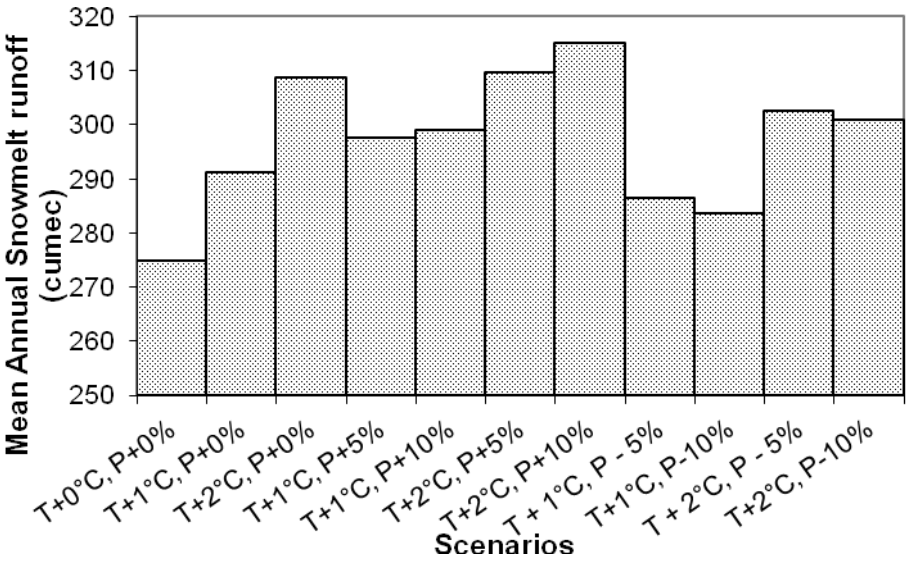


Fig. 3: Mean annual snowmelt runoff for various climate scenarios in Subansiri basin

n) Expected adopters:

State Water Resources Dept and other agencies dealing with Hydropower projects.

o) Deliverables:

Report and Research papers.

p) Data procured and/generated during the study:

- MODerate resolution Image Spectral radiometer (MODIS) snowcover data products (MOD10A2 8-day composite) for Subansiri River Basin for the years 2000-2009.
- SRTM DEM
- Daily rainfall data at few raingauges in the Indian part of Subansiri basin (2000-07)
- Daily rainfall data at 0.5 deg grid from APHRODITE for whole of the Subansiri basin (1970-07)
- Daily Temperature data at 1 deg grid from IMD for whole of Subansiri basin (1969-2005)
- Daily Temperature data at three stations in Indian part of Subansiri basin (2000-08)

q) Future plan:

As per the approved action plan.

2. PROJECT REFERENCE CODE: NIH/SWD/NIH/11-13

a) Title of study: **Impact of Climate Change on Glaciers and Glacial Lakes: Case Study on GLOF in Tista basin**

b) Study group: A.K. Lohani, Sc. 'E2' SWH Div., PI
Sanjay K. Jain, Sc. 'F', WRS Div., Co-PI
Rakesh Kumar, Sc. 'F' & Head SWH Div., Co-PI

c) Type of Study: Internal

d) Date of start: April 1, 2011

e) Scheduled date of completion: March 31, 2013

f) Statement of the problem:

In Himalayan region, 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. Proper planning and management of these projects depends on correct assessment of basin yield. The widespread glacial retreat in the Himalayas has resulted in the formation of many glacial lakes. Due to the recession of glaciers, a number of catastrophic affects such as glacial lake outburst floods (GLOF), water scarcity in the upper Himalayan villages and adverse effects on the flow of Himalayan rivers have been reported. For water resources planning and management, it is therefore essential to study and monitor the Himalayan glaciers and glacial lakes including GLOF. The study stresses the importance of methodologies used to assess impact of climate change on glacial lakes and the impact of glacial lake outburst floods (GLOFs) in Tista basin.

g) Objectives:

1. To prepare inventory of glaciers and glacial lakes using remote sensing data
2. To estimate flood hazard potential of most vulnerable lake glacial lake i.e. estimating the volume of water, peak discharge and corresponding flood hydrograph generated due to outburst of potential glacial lake.
3. To discuss GLOF Mitigation measures and early warning systems.

h) Study Area:

River Teesta or Tista is said to be the lifeline of the state of Sikkim, flowing for almost the entire length of the state and carving out verdant Himalayan temperate and tropical river valleys. The emerald-coloured river then forms the border between Sikkim and West Bengal before joining the Brahmaputra as a tributary in Bangladesh. The total length of the river is 315 km (196 mi). The river Teesta originates from Cholamo Lake in North Sikkim at an elevation of 5,330 m (17,487 ft) above sea level in the Himalayas. This lake lies to the north of the Donkia pass near Shetschen, where the summit of the pass is about eight kilometres north-east of Darjeeling. Potentially dengerous in the basi has been identified and the GLOF is routed from the lake to the outlet using the river cros-sections (Figure 1) delineated from the DEM.

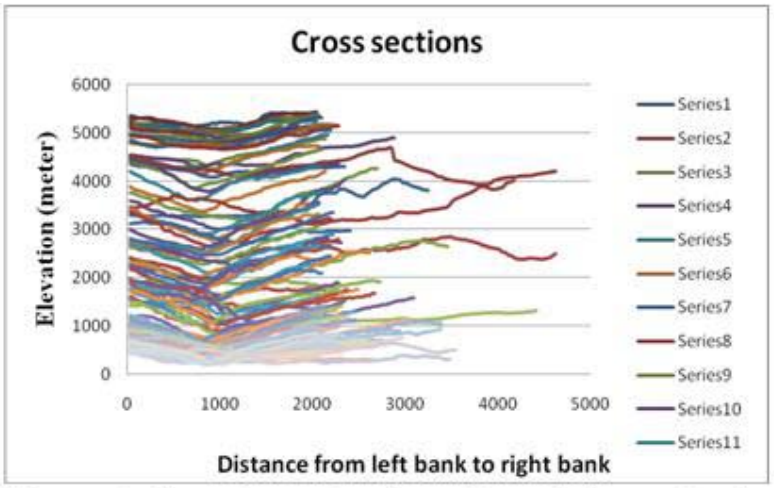


Figure 1: River Cross Sections from Lake to Outlet

i) Approved action plan :

Task	Apr. -Sep. 2011	Oct. 2011-Mar. 2012	Apr. -Sep. 2012	Oct. 2012-Mar. 2013	Status
Data Collection & Processing	═══				Completed
Preparation of inventory of glaciers and glacial lakes using remote sensing data, Glacial Lake Outburst flood modelling	═══	═══			Completed
Glacial Lake Outburst flood modelling		═══	═══		**In progress**
GLOF Mitigation measures and early warning systems Report writing			═══	═══	

j) Achievements

Year	Objectives (for the period April 2011 to September 2011)	Achievements
April, 2011 to March 2013	1. Data Collection & Processing	Completed
	2. Creation of Basin map	Completed
	3. Creation of data base in GIS	Completed
	4. Classification of data for lake inventory	Completed
	5. Identification of glaciers and lakes	Completed
	6. Methodology for GLOF	Completed
	7. Glacial Lake Outburst flood modeling	Completed
	8. Draft Report	Completed

k) Role and Responsibility of Team Members:

Dr. A.K. Lohani: Data Collection, Data Processing, Simulation of glacial lake outburst using MIKE 11

Dr. Sanjay Kumar Jain: Data Collection, Data Processing, Preparation of data base, inventory of glaciers & lakes etc.

Dr. Rakesh Kumar: Data Processing, Data Analysis, Interpretation of results etc.

l) Recommendation/suggestions in previous meetings of WG / TAC / GB

There was no specific recommendation pertaining to the study.

m) Analysis and results:

The basin map of the study area has been prepared. Further, DEM of the study area has been created in order to analyse the topography for identification of river cross sections. Remote sensing data of Landsat TM have been downloaded from Internet. Using conventional and SVM techniques, classification of this data has been carried out for identification of glaciers and glacial lakes. From the classified remote sensing data preparation of glacial lakes inventory is in progress. In order to simulate GLOF, methodology has been finalisied using sample data sets (Figure 2). Further, glacial lakes and potentially dangerous lakes have been identified. Glacial Lake outburst flood modeling has been carried out using Mike11 model for the selected lake (Fig.3).

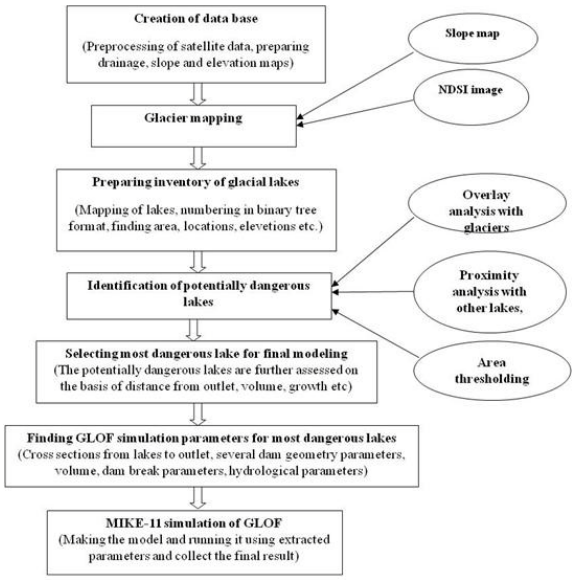


Figure 2: Glacial Lake outburst flood modeling usin Mike-11

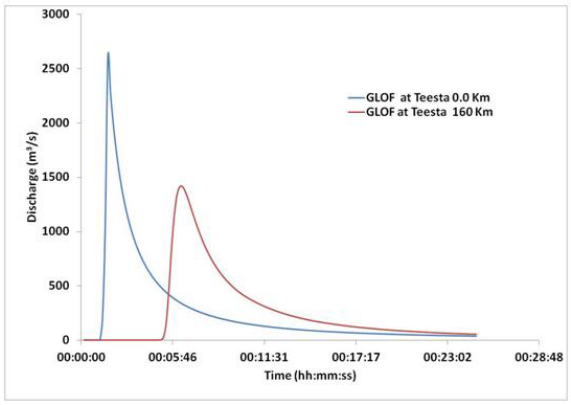


Figure 3: Glacial Lake outburst flood at lake and selected project site

n) Deliverables:

Reports and research papers

o) Data generated in the study:

Inventory of glacial lakes, vulnerable lakes and simulation of vulnerable lakes

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

a) Title of the Study Basin Techniques : **Climatic Scenarios Generation for Satluj using Statistical Downscaling**

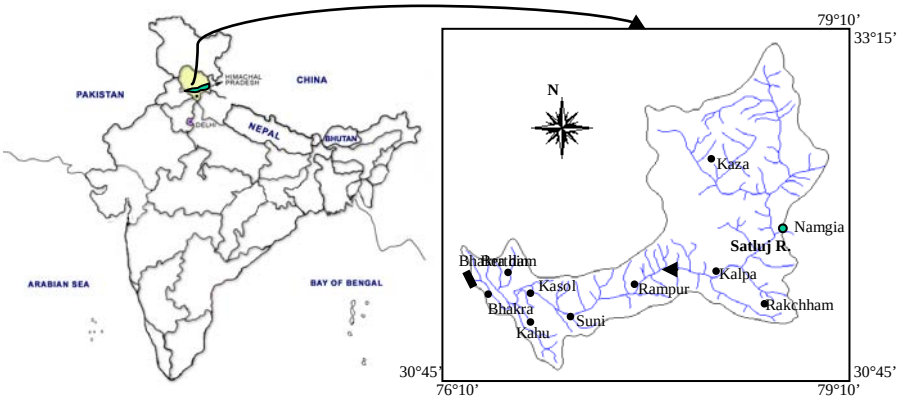
b) Study Group: Manohar Arora Sc 'C', SWH Div.
Rakesh Kumar Sc 'F', SWH Div.

c) Type of study: Internal

d) Date of Start: 1.04.2010

e) Scheduled date of completion: 31.03.2013

f) Location map:



g) Objectives: The objectives of the study are:

i. To Downscale the GCM Output of CMIP3 models.

ii. To predict future climatic scenarios for Satluj basin.

h) Statement of the problem:

For studying the impact of climate change the future climatic scenarios are needed. These scenarios will be downscaled for the Satluj basin using statistical downscaling technique.

i) Approved action plan:

Year	April – June	July-Sept	Oct-Dec	Jan-March
2010	Literature Survey	Literature Survey	Dev. of Methodology	Development of Methodology & Data Collection
2011	Data Processing	Data Processi	Downloading of GCM	Preliminary processing of GCM

		ng	output	
2012	Analysis of data	Analysis of data	Preparation of report	Preparation of report

j) Role and Responsibility of Team Members:

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

k) Objectives vis a vis achievements:

Development of Methodology & Data Collection	The tentative methodology has been developed. The data has been collected.

l) Recommendation/Suggestion of Working Group:

No specific recommendation

m) Analysis & Results:

The data has been downloaded and the procedure for AO quantitative evaluation has been finalized. The quantitative evaluation has been carried out for the CMIP 3 models and it has been found that nearly 5 models out of 24 models are performing better for the region. The future scenarios were determined for the GCM model Micro_3_2_hires. It is found that this model output was better in comparison to others. The 20 year average monthly rainfall comparison of past and future shows that there will be some reduction in rainfall for the monsoon period.

month	OBS	micro_3_2_hires
1	1.81	1.80
2	2.03	2.04
3	1.72	1.71
4	1.02	0.99
5	1.50	1.53
6	3.42	3.40
7	13.57	13.19
8	13.16	13.15
9	6.36	6.41
10	0.90	0.89
11	0.58	0.71
12	1.30	1.17

.

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

The study will benefit the departments like SJVNL and BBMB.

o) List of deliverables:

1. Case study in the form of report
2. Papers will be outcome of the study**.**

p) Major items of equipment procured: Nil

q) Lab facilities during the study: Desktop study.

r) Data generated in the study: Data will be downloaded from NOAA site.

s) Study Benefits/Impact: The study will develop the capabilities to downscale future climatic scenarios at basin scale. This scenarios generated may be used to assess the impact of climate change

t) Specific linkages with Institutions/beneficiaries: The results will be shared with BBMB and SJVNL.

u) Shortcomings/Difficulties: This is the first study of this kind being taken up. As more and more downscaling at basin scale is done the methodology will become robust.

v) Future Plan: The climatic scenarios generated will be used for assessment of impact of climate change on runoff.

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

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

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

c) Type of study: Internal

d) Date of start: Nov. 2010

e) Scheduled date of completion: Oct. 2013

f) Location map / study area:

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

g) Objectives of the study:

i. Development of rainfall-runoff, rainfall-spring flow relationships and assessment of climatic variability.

ii. Estimation of impact of climatic variability on runoff and spring flow.

iii. Detailed hydrological monitoring, collection of data at watershed scale and creation of a centralized database for watershed for the benefit of the users.

iv. Development of implement able technology for water availability and transfer of developed technology to users.

h) Statement of the problem:

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

i) Approved action plan:

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

		development of model		collected during 2011
2012	Development of appropriate model	Interactive workshop	Interpretation of results	Processing and analysis of data collected during 2012
2013	Analysis of current data with historical data	Interactive workshop	Preparation of report	

j) Role and Responsibility of Team Members:

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

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

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

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

No specific comments/ recommendation.

l) Analysis of results:

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

m) Results in brief:

- **Maintenance and up keeping of installed equipments.**
- **Rainfall runoff and spring Flow analysis.**
  Monthly rainfall runoff relationships are developed for monsoon, non-monsoon and total period. Monthly cumulative rainfall and spring flow indicated a high correlation for all springs in both the watersheds. Total rainfall and spring flow is also highly correlated. The recession of the springs can be given with polynomial, power and log relationship. Generalized relationships are developed for both watersheds. Rain to spring lag on daily

and monthly basis is identified. Spring flow variability is related with spring lag.

- **Processing and analysis of data collected up to December 2012.**
  The data collected till December 2012 is incorporated.

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

o) Major items of equipment procured: Nil

p) Lab facilities used during the study: Nil

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

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

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

t) Shot comings/ difficulties: Nil

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

5. ROJECT REFERENCE CODE: NIH/SWD/NIH08-

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

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

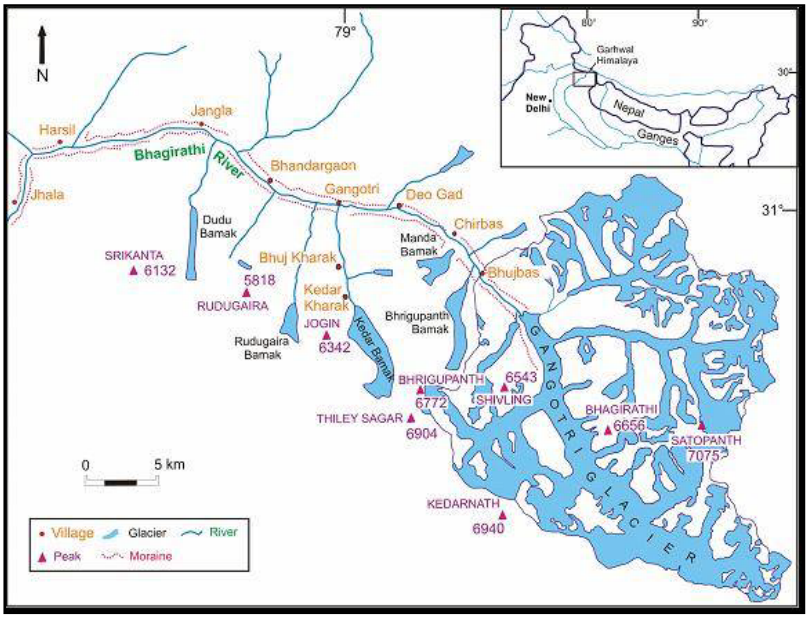
Rakesh Kumar Sc 'F', SWH Div.

c) Type of study: Internal

d) Date of start: 01.04. 2008

e) Scheduled date of completion: Long term study

f) Location map:



g) Objectives of the project:

The objective of this study includes:

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

ii. To improve the hydrological model for simulating daily streamflow

h) Statement of the problem:

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

i) Approved action plan:

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

j) Role and Responsibility of Team Members:

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

k) Objectives vis a vis 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 2012 were completed. The analysis has been completed on collected data.
To improve the hydrological model for simulating daily streamflow	The simulation of flow will be carried out after collection of three years of data.

l) Recommendations of Working Group/TAC/GB:

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

m) Analysis and Results:

The data collected for 2011 and 2012 were analysed and interim report was prepared. Average monthly rainfall for June, July, August and September has been computed to be 21.0, 39.5, 103.2 and 24.8 mm, respectively. The total rainfall and its distribution over the summer season are found to vary from year to year. For example, the total rainfall for the summer season (May to September) for 2011 and 2012 was recorded to be 293 and 128 mm. Based on 2 years data average seasonal rainfall for the Gangotri Glacier was observed to be about 210.5 mm. The average daily maximum and minimum temperatures over the summer season were computed to be 14.8 ^{o}C and 5.3 ^{o}C, respectively, whereas average mean temperature was 10.0 ^{o}C. Diurnal variations in temperature indicate that generally maximum temperature is observed sometimes around 1400 hours while the minimum at the early morning. Mean monthly temperatures for June, July, August and September were 15.7, 14.9, 14.8 and 13.6^{o}C, respectively, suggesting that June was the warmest month. Analysis of wind data shows that on an average the daytime wind speeds are much stronger (4 times) than the nighttime winds. On the seasonal scale daily mean sunshine hours were 4.1 hours. Monthly total pan evaporation was 128.0, 105.4, 73.5, and 90.8 mm for the month of June, July, August and September respectively. The discharge showed increasing trend from May onward, reached to its highest value in July and then started reducing. The maximum and minimum daily mean discharge observed during study period was 14.5 to 159.5 m^3/s. The mean monthly discharge observed for June, July, August and September was 27.6, 69.7, 105.6 and 47.7 m^3/s, respectively. Almost similar trend of distribution of runoff is observed for all the years. The strong storage

characteristics of the Gangotri Glacier are reflected by the comparable magnitude of runoff observed during daytime and night time. Mean monthly suspended sediment concentration for May, June, July, August and September during the study period was 754, 1321, 2040, 1606 and 626 ppm, respectively. Mean monthly total suspended sediment loads for May, June, July, August and September during the study period was found to be 42, 209, 401, 255 and 60 $\times 10^2$ tonnes respectively.

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

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

o) List of deliverables:

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

p) Major items of equipment procured: Nil

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

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

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

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

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

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

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

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

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

c) Type of Study: Internal

d) Date of start: April, 2011

e) Scheduled date of completion: March, 2014

f) Location map:

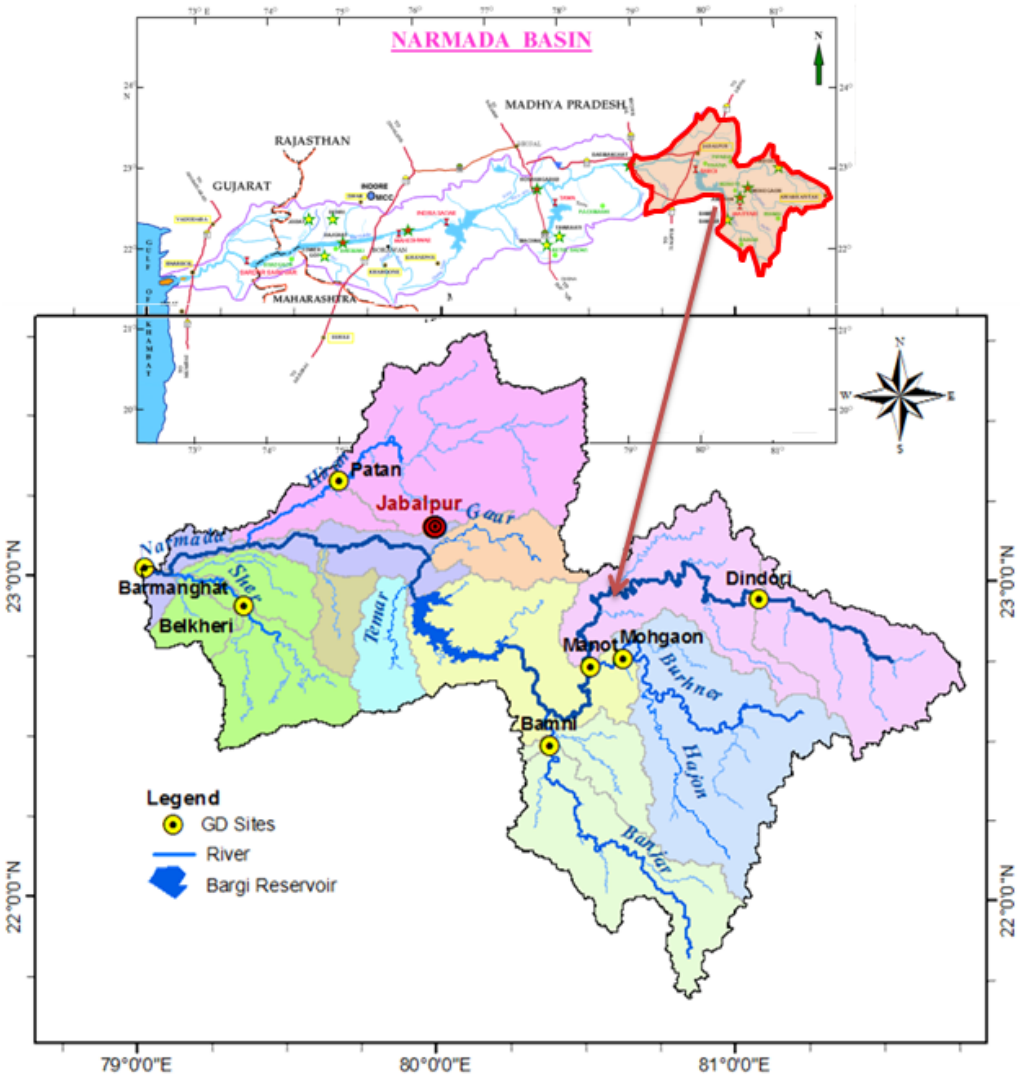


Fig. 1: Location map of study area.

g) Study objectives:

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

(ii) Rainfall runoff modelling.

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

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

(v) Dam break flood wave simulation.

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

h) Statement of the problem:

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

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

i) Approved action plan and timeline:

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

j) Role and Responsibility of Team Members:

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

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

k) Brief methodology:

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

l) Results achieved with progress/ present status:

During past six months Mike 21 and Mike Flood model setup were prepared. Bathymetry (Fig. 2) of 180m cell size for downstream of Bargi dam has been prepared from the DEM. The Landsat-7 image was classified to prepare LCLU map and resistance (Manning number) file for mike 21 was derived form it. This Mike 21 model is linked (Lateral linked to both left and right of river) with 1-D Mike 11 model in Mike flood as shown in figure 3.

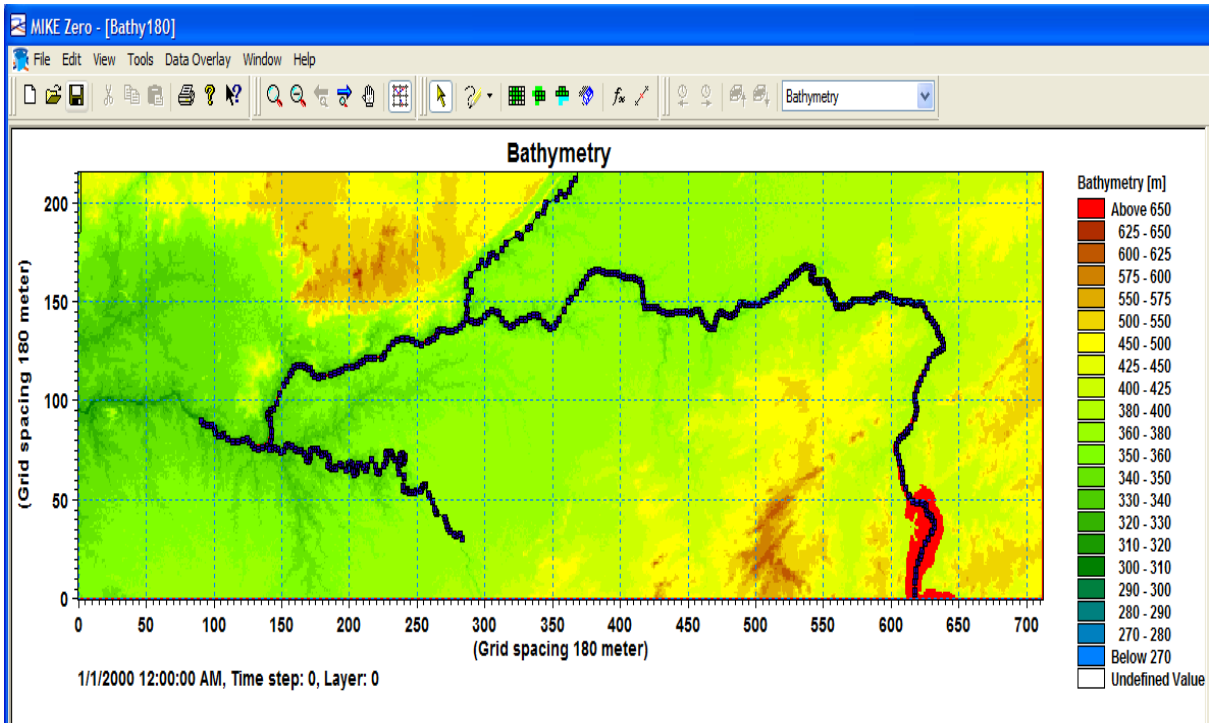


Fig. 2: Bathymetry for Mike-21 model setup

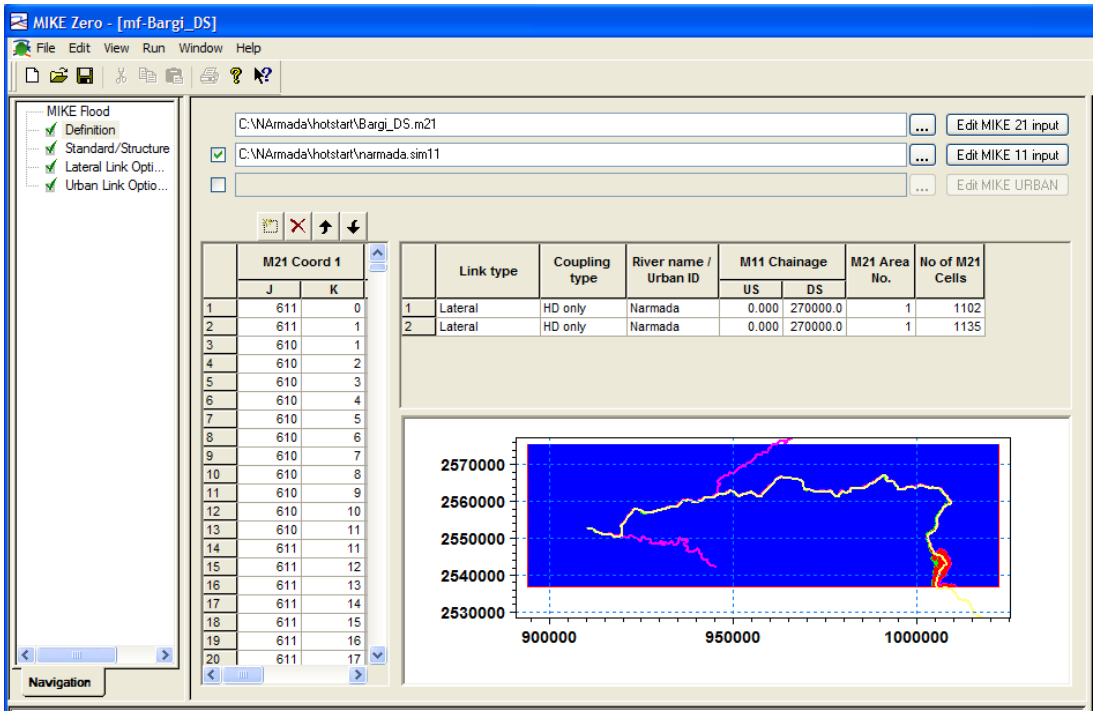


Fig. 3: Coupling of Mike 21 and Mike 11 in Mike Flood.

m) **Action taken on comments of previous working group meeting**

There were no specific comments

n) List of deliverables:

Papers and reports.

o) Data collected/generated:

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

p) Involvement of end users / beneficiaries:

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

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

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

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

c) Type of study: Internal

d) Date of start: April 2012

e) Scheduled date of completion: March, 2015

f) Location map / study area: Paisuni (Mandakini) Basin in Chitrakoot District

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

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

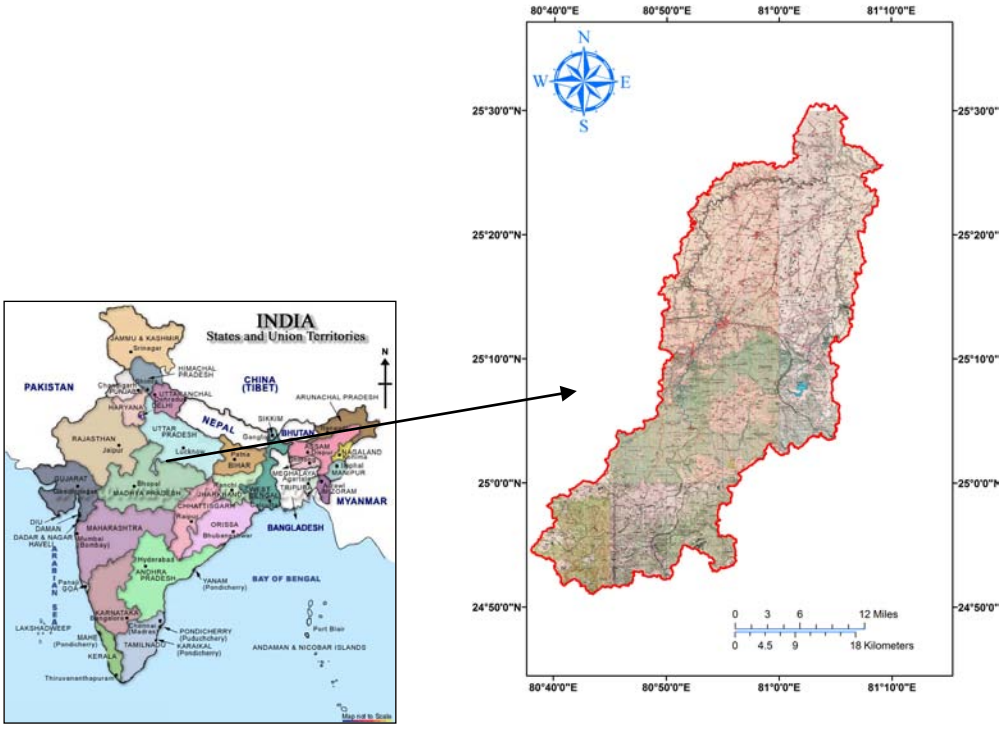


Fig. 1: Location Map of Paisuni Basin

g) Objectives of the study:

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

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

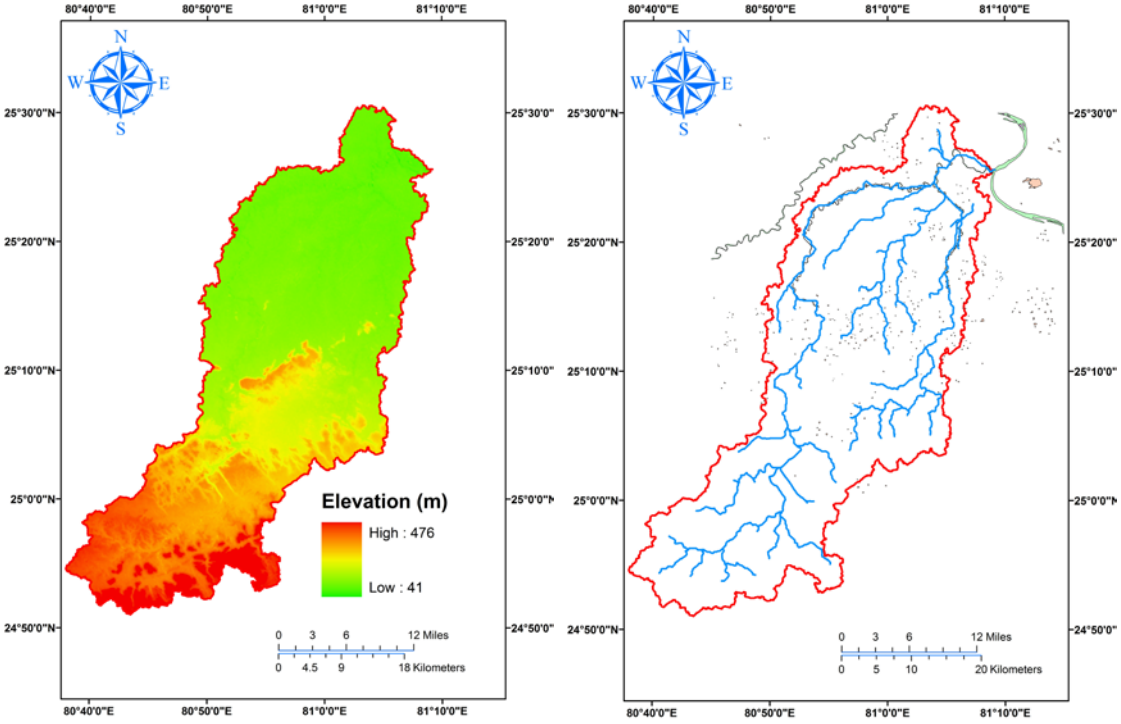
h) Time schedule:

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

i) Progress of proposed study:

- Conducted field visit for collection of data/information collection from various sources in the proposed study areas.
- Procured GIS data in soft copy from Remote Sensing Application Centre, UP and collected daily rainfall data from district office.
- Prepared some of base maps of drainage, land-use, DEM, maps etc. using GIS.

- Procured various maps and Gazetteer and gathered other local information to prepare Inventory of past drought events in the study areas.
- Analyzed rainfall data to determine frequency and severity of droughts in past decades.
- Applied and compared SPI and EDI with A New Methodology (named as SDI, simple drought index) to assess attributes of drought events.
- Analyzed critical dry spell fro past 50 year data and estimated supplemental irrigation requirement for crop saving during CDS and drought.



DEM Map

Drainage Map

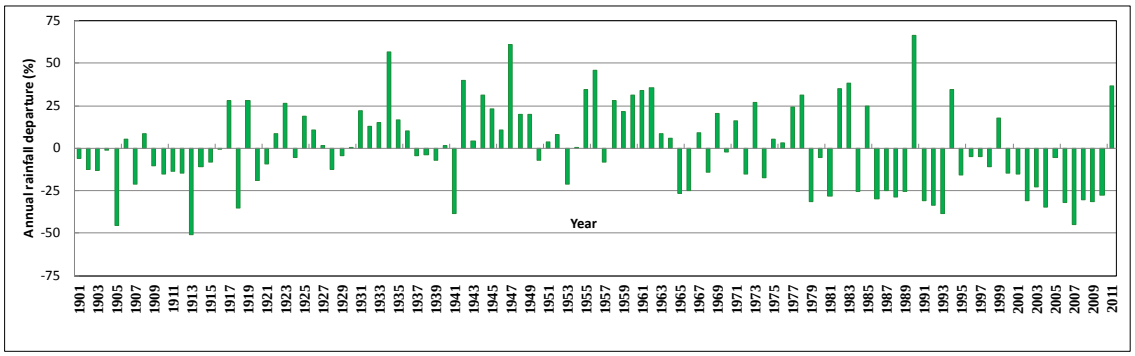


Table : Frequency and severity of droughts in Chitrakoot district

S. No.	Station	Data range	Drought years	Percentage departure	Severity of drought	Average drought frequency
1.	Karwi	1950-51 To 2009-10	1965-66	-36.04	Moderate	1in 5 years
			1966-67	-40.23	Moderate	
			1968-69	-37.01	Moderate	
			1973-74	-51.16	Severe	
			1976-77	-48.36	Moderate	
			1987-88	-41.29	Moderate	
			1988-89	-25.60	Moderate	
			1989-90	-46.21	Moderate	
			2004-05	-21.68	Mild	
			2006-07	-25.62	Moderate	
			2007-08	-70.99	Severe	
			2008-09	-49.58	Moderate	
			2009-10	-34.90	Moderate	
2.	Mau	1950-51 To 2009-10	1963-64	-26.86	Moderate	1in 5 years
			1965-66	-45.41	Moderate	
			1968-69	-50.47	Severe	
			1972-73	-30.15	Moderate	
			1973-74	-32.89	Moderate	
			1987-88	-32.35	Moderate	
			1988-89	-58.67	Severe	
			1989-90	-60.59	Severe	
			2006-07	-27.89	Moderate	
			2007-08	-36.81	Moderate	
			2009-10	-31.30	Moderate	

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

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

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

- An interim report of the study is to be prepared and submitted in April 2015.
- This study will yield suitable approach to quantify drought attributes, area specific assessment of water availability, demand and magnitude of deficit.
- Two training courses each for one week duration will be organized to disseminate the knowledge and output of the study during 2013-14 and 2014-15.

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

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

b) Study group: A. R. Senthil kumar Sc E1 & P.I., SWH Div.
Manohar Arora, Sc C, SWH Div.
Suhas D Khobragade, Sc E1, HID
Avinash Agarwal, Sc F, SWH Div.
Sanjay K. Jain, Sc F, WRS Div.

c) Type of study: Internal

d) Date of start: 1 April 2012

e) Scheduled date of completion: March 31, 2015

f) Study objectives:

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

g) Brief methodology:

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

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

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

Revision of elevation-area-capacity table
The computed sediment volume for future periods is distributed in the reservoir by empirical area reduction method.

h) Results achieved with progress/present status
The monthly rainfall at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam are computed from the daily values of rainfall from 1987 to 2009. The monthly flow volume (*Mm^3*) and sediment yield (*MTons/month*) at Jwala Mukhi (located on Beas) for the same period are computed from daily values of sediment yield and discharge. The correlation analysis between monthly rainfall (*mm*) and flow

volume (Mm^3) with monthly sediment load (*MTons/month*) is carried out and is given in the following table.

Parameter	Sediment load at Jwala Mukhi
Rainfall at Dehra Gopipur	0.74
Rainfall at Haripur	0.71
Rainfall at Nangal Chowk	0.68
Rainfall at Pong Dam	0.67
Flow volume at Jwala Mukhi	0.82

The above table indicates that the rainfall at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam and flow volume at Jwala Mukhi have reasonably good correlation with sediment load at Jwala Mukhi. So the following combination is considered as best input vector to the ANN model.

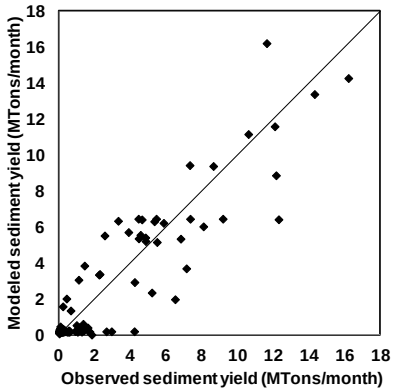
Sedyld(t) = f(flowvol(t), raindehra(t) rainhari(t) rainnangch(t) rainpondam(t))

in which *Sedyld*, *flowvol, raindehra, rainhari rainnangch and rainpondam* are sediment yield, flow volume at Jwala Mukhi and rainfall values at Dehra Gopipur, Haripur, Nangal Chowk and Pong dam respectively. The feed forward ANN is trained with input vector as mentioned above. The monthly data from 1987 to 2007 are considered for the training of the model since it contains the extreme values of sediment load. The data from 2008 to 2009 are considered for the validation of the model. The performance of the ANN model during calibration and validation is given in the following table.

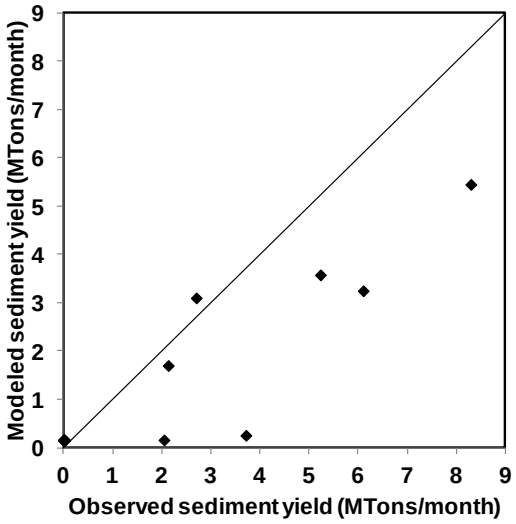
Model No	Input combinations	ANN Structure	Calibration			Validation		
			CORR	RMSE MTons	EFF%	CORR	RMSE MTons	EFF%
ANNSY 1	flowvol(t), raindehra(t), rainhari(t), rainnangch(t), rainpondam(t)	5-1-1	0.86	1.34	75.00	0.94	0.78	88.00
ANNSY 2	,,	5-2-1	0.93	0.97	86.60	0.91	1.21	72.00
ANNSY 3	,,	5-3-1	0.92	1.66	86.00	0.88	1.65	47.00
ANNSY 4	,,	5-4-1	0.96	0.67	93.00	0.80	1.73	42.00

The results from the above table indicate that the performance of the different ANN structure in simulating the sediment yield during calibration is increased as the number of nodes in the hidden layer increased. But it is decreased during the

validation of the model. Based on the overall performance of all the combinations, the model ANNSY2 (calibration: CORR= 0.93, RMSE=0.97, EFF=86%; validation: CORR= 0.91, RMSE=1.21, EFF=72%) is selected as the best ANN model for simulating the sediment yield at Jwala Mukhi and the optimum structure of the ANN model is found to be 2 neurons in the hidden layer. The performances of the best ANN model during calibration and validation are given in the following figures.



The performance of ANN model during calibration at Jwala Mukhi



The performance of ANN model during validation at Jwala Mukhi

i) Expected date of completion: 31 March 2015

NEW STUDIES PROPOSED FOR 2013-14

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

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

b) Study Group: A.K. Lohani, Sc. 'F', SWH Div. P.I.

c) Type of study: Internal

d) Date of Start: April 1, 2013

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

f) Study Area:

The river Mahanadi is an interstate river originating from Chhatisgarh and reaches Bay of Bengal travelling 851 km. More than 99% of its catchment lies in these two states. The basin is basically divided into 3 parts(Fig.1). The upstream catchment (Catchment area=83500sq.km.) covers mostly hilly region of Chhatisgarh. The second middle catchment (Catchment area = 48535 sq.km.) covers the area downstream of Hirakud and before delta. The third part is the flood prone part of delta (Catchment area=9034sq.km, including Chilika lake). The drainage capacity of deltaic rivers is up to 10 lakh cusecs (Patri, 2008). So a discharge of above 10 lakh cusecs can create flood havoc.

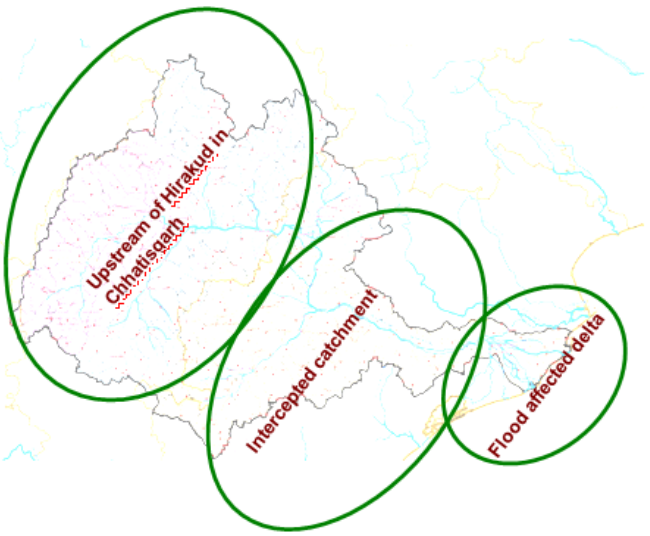


Figure-1, Mahanadi basin divided into 3 important segments

g) Objectives:

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

h) Statement of the problem:

Floods are among one of the most destructive acts of nature. Worldwide flood damages to agriculture, house and public utilities amount to enormous amount in addition to loss of precious human and cattle lives. They present risks which can be high especially if they are ignored or proper precautions are not taken. Though human influence nature more and more in the present world, nature is still able to surprises us through these hazards.

Flood forecasting is used to provide warning to people residing in flood plains and can alleviate a lot of distress and damage. Flood forecasting is an important non structural solution for reducing flood damages and is used to provide warning to people residing in flood plains. Conventional methods of flood forecasting are based on either simple empirical black box which do not try to mimic the physical processes involved or uses complex models which aim to recreate the physical processes and the concept about the behaviour of a basin in complex mathematical expressions (Lohani, 2005). A real time flood forecasting system for flood forecasting may provide flood and water level information at the forecasting site with increased accuracy and lead time.

i) Action plan:

Task	**Apr-June 2013**	**July-Sept. 2013**	**Oct.-Dec. 2013**	**Jan. 2014 Mar. 2014**	**Status**
Identification of the study basin					
Data Collection & Processing					
Development of Rainfall-Runoff Model					
Development of Flood Forecasting model					
Development of Real time flood forecasting model					

j) Deliverables:

Real Time flood forecasting system Methodology, Reports and research papers

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

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

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

c) Type of study: Internal

d) Date of Start: April 1, 2013

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

f) Study Area:

The study area will be finalized on the basis of the availability of hydrological data.

g) Objectives:

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

h) Statement of the problem:

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

i) Action plan:

Task	Apr. - Sep. 2013	Oct.-Mar. 2013	Apr.-Sep. 2014	Oct. 2013-Mar. 2014	Status
Identification of the study basin					

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

j) Role and Responsibility of Team Members:

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

Dr. Surjeet: Data Collection, Data Processing, Simulation

Rahul Jaiswal: Data Collection, Data Processing, Simulation

k) Deliverables:

Reports and research papers

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

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

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

c) Type of study: Internal

d) Date of start: April 2013

e) Scheduled date of completion: March, 2014

f) Objectives of the study:

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

g) Statement of the problems:

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

h) Proposed methodology:

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

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

i) Time schedule:

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

j) Adopters of the study:

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

k) Deliverables

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

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

l) Major items of equipment procured: Nil

m) Lab facilities during the study: Nil.

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

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

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

c) Type of study: Internal

d) Date of start: April 2013

e) Scheduled date of completion: March, 2016

f) Objectives of the study:

The objectives of the study are:

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

g) Statement of the problems:

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

h) Proposed methodology:

Statistical methods/tools and the procedures described in various ISO documents (GUM, HUG) will be used for the estimation of river discharge uncertainties. The uncertainty in discharge measurement (assuming velocity area method) will be quantify as per the ISO 748 which provides the magnitude of these errors at 95% confidence level. The uncertainty affecting discharge observations can be obtained by integrating the individual sources of errors as

$$X_Q = \pm\sqrt{X_m^2 + \frac{1}{m}(X_e^2 + X_c^2 + X_p^2 + X_b^2 + X_d^2)}$$

Where X_Q is the uncertainty in the discharge measurement due to uncertainty in point flow velocity (X_e); uncertainty affecting the rating of the rotating element of the current meter (X_c) uncertainty in mean velocity (X_p) along each vertical segment, uncertainty in width (X_B), uncertainty in depth (X_d) and, uncertainty X_m in the estimation of mean velocity over the cross section.

The uncertainty of the computed value of discharge Q_c at gauge height h, u(In Q_c(h), is found from the following equations (ISO/TR 7066-1)

$$u\left(lnQ_c(h)\right) = S\left\{\frac{1}{N} + \frac{[\ln(h-e) - \overline{\ln(h-e)}]^2}{\sum[\ln(h-e) - \overline{\ln(h-e)}]^2}\right\}^{0.5}$$

Where, (h-e) is the effective depth of the water at control and S is the standard error of estimate of the rating curve.

i) Data requirements:

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

j) Action plan Time line:

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

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

l) Deliverables: Research papers, reports

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

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

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

c) Type of study: Internal

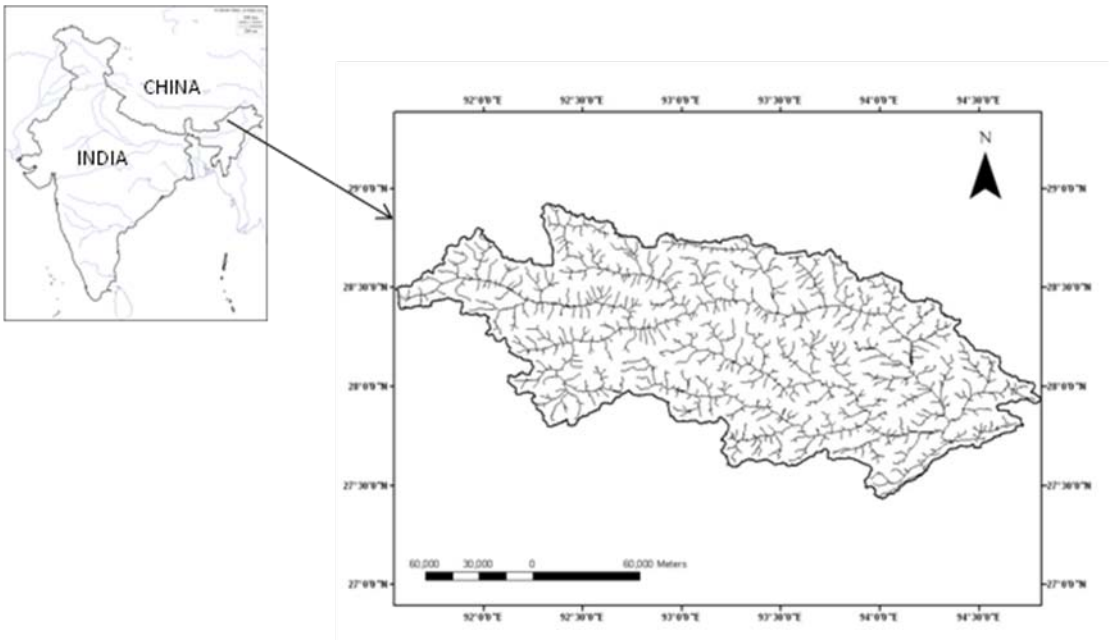
d) Date of start: 1 April 2013

e) Scheduled date of completion: 31 March, 2014

f) Nature of study: Model development

g) Study area/Location map

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



h) Objectives of the study:

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

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

iii. Intercomparison of developed models

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

i) Statement of the problems:

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

j) Methodology:

ANN based Suspended Sediment Flux simulation models

Back propagation feed forward ANN models would be developed to simulate the suspended sediment flux for the catchment of Subansiri River up to Choudhuaghat gauging site using various combinations of the historical data of rainfall, rainfall intensity, temperature, snow cover area, discharge and suspended sediment concentration on daily, ten-daily and monthly basis.

Conventional Models for simulation of Sediment Flux

Sediment rating curves (SRC) and multiple linear regression (MLR) models would be developed to simulate the suspended sediment flux for the catchment of Subansiri River up to Choudhuaghat gauging site using data similar to that used for ANN models

Inter-comparison of Models

An inter-comparison of the models with same input data would be carried out in order to find suggest the best model.

This study would conclude by providing discussion about how the different type of input data, length of input data, lagging of input data and scale of input data effect the accuracy of sediment flux estimation in a large Himalayan River basin and also guidance on the types of tasks for which different types of input data may be preferable.

k) Action plan and time line:

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

l) Data requirement:

i. Daily rainfall, mean temperature and snow cover area in the basin
ii. Daily discharge and suspended sediment concentration at Chouldhuaghat site

m) End users/beneficiaries of the study

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

n) Deliverables

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

WATER RESOURCES SYSTEM DIVISION

Scientific Manpower

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

WORK PROGRAMME FOR THE YEAR 2013-14

S.N.	Title	Study Team	Duration	Funding
Ongoing Internal Studies				
1.	Mathematical representation of Elevation-Area-Capacity curves for Indian reservoirs	M. K. Goel Sushil K. Singh P. K. Agarwal	1 year (4/12-3/13) **Completed study**	NIH
2.	Event-based rainfall runoff modelling using soft computing techniques	Rama Mehta Sushil K. Singh Yatveer Singh	1 year (4/12-3/13) **Completed study**	NIH
3.	Analysis of water management scenarios in Tapi river basin using MIKE basin software	Rama Mehta M.K.Goel D.S.Rathore	3 years (4/10-3/13) **Completed study**	NIH
4.	Web GIS based snow cover information system for Himalayas	D. S. Rathore D. Chalisgaonkar L. N. Thakural Tanvear Ahmed	1 year (4/12-3/13) **Completed study**	NIH
5.	Software for frequency analysis in Hydrology	D. Chalisgaonkar D. S. Rathore Sushil K. Singh M. K. Goel	1 year (4/12-3/13) **Completed study**	NIH
6.	Trend and variability analysis of rainfall and temperature in Himalayan region	L.N.Thakural Sanjay Kumar Sanjay K. Jain Sharad K. Jain Tanvear Ahmed	3 years (10/11-09/14) **Continuing study**	NIH
Sponsored Studies				
1.	Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin	Sanjay K. Jain S. P. Rai L. N. Thakural	3 years (4/09-12/13) **Continuing study**	PDS (HP-II)
2.	Assessment of effects of sedimentation on the capacity/life of Bhakra reservoir (Gobind sagar) on river Satluj and Pong reservoir on river Beas	Sanjay K. Jain J. V. Tyagi Rama Mehta	3 years (4/09-6/13) **Continuing study**	PDS (HP-II)
3.	Hydrological assessment of Ungauged Catchments (Small catchment)	P.K. Bhunya Rakesh Kumar Sanjay Kumar D.S. Rathore P.C. Nayak	4 years (5/09-3/13) **Completed study**	PDS (HP-II)
4.	Ganga basin R&D project	Sharad K. Jain Sanjay K. Jain		
New Internal Studies				
1.	NIH_Basin A WINDOWS based model for water resources assessment in a river basin	M.K. Goel S.K. Jain D. Chalisgaonkar P.K. Mishra	2 years (4/13-3/15) **New study**	NIH

2.	Impact of climate and landuse change on floods of various return periods	P.K. Bhunya Sanjay Kumar D.S. Rathore	2 years (4/13-3/15) **New study**	NIH
3.	Web GIS based snow cover information system for the Himalaya	D.S. Rathore D. Chalisgaonkar L.N. Thakural T. Ahmed	2 years (4/13-3/15) **New study**	NIH
4.	Assessment of Water Footprint of the National Capital Territory (NCT) of India	D. Chalisgaonkar Sharad K. Jain P.K. Mishra	2 years (4/13-3/15) **New study**	NIH
5.	Assessing climate change impact across KBK region of Odisha	P.K. Mishra Sharad K. Jain Sanjay K. Jain P K Bhunya	2 years (4/13-3/15) **New study**	NIH

ONGOING/ COMPLETED INTERNAL STUDIES

Study 1:

Title: Mathematical representation of Elevation-Area-Capacity curves for Indian reservoirs

Study Group	**-**	M. K. Goel, Sc. "F" Sushil K. Singh, Sc. "F" P. K. Agarwal, PRA
Type of Study	**-**	Internal
Start Date	**-**	April 04, 2012
Scheduled date of completion	**-**	31st March, 2013

Objective of the study:

The envisaged objective of the study is to develop mathematical relationships for characterizing elevation – area and elevation – capacity curves for Indian reservoirs.

Proposed Methodology:

Elevation – Area and Elevation – Capacity curves for a number of Indian reservoirs are available. It is proposed to divide the reservoirs in four different types according to the shape of the gorge and characteristics of submergence area (Gorge, hill, foothill, and plain etc.) and to analyze these curves for various reservoir types for developing mathematical relationships. If suitable relationships could be established, then it would be easier to use such relationships in various simulation studies.

Achievement

Objectives (Oct 2012 – till date)	Achievements
1. Application of methodology to known EACs of some reservoirs.	1. The methodology has been developed in MS-EXCEL and EAC curves (or normal and log scale) have been plotted for around 80 reservoirs: a) Original and revised (if any) E-A-C table of the reservoir is tabulated. b) E-A and E-C curves, on normal and log scales, are plotted. c) The type of reservoir, depending on the value of 'm', is determined. d) Separate sheets are prepared for analysis of E-A curves and E-C curves for different type of reservoir. e) In these sheets, relative depths and relative areas/capacities are determined and plotted on normal and log scales.

	f) Considerable data of 78 reservoirs, whose weekly information regarding elevation and capacity is received from CWC, have been computerized and efforts are underway to prepare such curves for these reservoirs also.

Analysis & results

The developed approach is presented in table above. Based on the E-A and E-C curves for different types of reservoirs, it is planned to combine the E-A and E-C curves of different reservoirs (of similar type) in a single graph and estimate the mathematical function best representing the available graphs. The analysis is in progress.

Adopters of the study and study benefits:

This study can be used in the river basin planning models for approximate representation of the elevation-area and elevation-capacity relationships of a large number of reservoirs in a system.

Deliverables:

Research papers and reports.

Data generated in the study

No data is being generated in this study. Rather, this study utilizes the known data of E-A-C table of a large number of Indian reservoirs.

Study benefits/impacts

The study can help in various simulation studies and in planning and management studies for reservoir projects and analysis for river basin planning.

Study 2:

Title: Event-based rainfall-runoff modeling using soft computing techniques

Study group:

Scientists:	Rama Mehta, Scientist C (PI)
	Sushil K. Singh, Scientist F (co-PI)
Scientific staff:	Yatveer Singh, S.R.A.
Date of start of study:	April 2012
Duration:	01 year
Date of completion:	March 2013
Funded	Internal

Objectives

Model the event-based rainfall-runoff using soft-computing techniques considering the basin-wise multi-storm data.

Statement of problem and brief methodology

Modeling of rainfall-runoff plays an important role in the design and operation of hydraulic systems. Unit response of catchment can be obtained using traditional approaches such as linear programming and least square methods. A lot of information can be obtained during the event because the system is under greater excitation during storms. Scarcity of hydrological data poses practical problems for the application of more complex models (either conceptual or physically-based) for runoff modeling. In such cases, system based approach is another alternative for modeling. During last decade, there has been an increased interest in applying new emerging techniques as Fuzzy Inference System (FIS) and Artificial Neural Network (ANN) for solving hydrological problems.

With consideration of event based rainfall –runoff, unit response of the system is intended to be developed with ANN and ANFIS techniques. The proposed model is intended to be developed and tested with published event based data of different catchments. It is intended to apply this technique also to a specific Indian basin.

This study explores the application of neuro-fuzzy inference systems for event-based rainfall-runoff modeling. These models intend to describe the non-linear relationship between input/antecedent and output/consequence to the real system. Models are developed by Artificial Neural Fuzzy Inference System (ANFIS) - grid and cluster techniques, which identified suitable numbers of fuzzy if-then rules through proper partition of the input space. Three variables as rainfall, temperature and evaporation are considered as antecedent and runoff as consequence of the model. The input variables are fuzzified with trapmf, gbellmf or guassmf membership functions (Jang et al, 1997) to develop the fuzzy rules. The consequent function is chosen to be linear or constant in their parameters, and a standard least square error method is employed for parameter estimation. The first stage in the inference process of a TS fuzzy model is the calculation of the degree of fulfillment (DOF) of each rule. The output of each rule is obtained by the evaluation of the membership values. Finally the overall fuzzy model response is obtained as the weighted

average of the individual rule response.

To evaluate the performance of developed model, different evaluation criteria will be considered while comparing the observed and simulated runoff hydrographs. These criteria include the root mean square error (RMSE), standard error of estimate (SEE), Nash and Sutcliffe (1970) criterion, a recently proposed criterion considering the multiple isolated storm.

Action plan

Activity	I-Quarter	II-Quarter	III-Quarter	IV-Quarter
Review of literature and collection of data				
Development and application of soft computing methods for rainfall-runoff modelling				
Testing, evaluation, and comparison with different methods				
Writing of report				

Action Taken:

Quarter	Objectives	Achievements
Ist	Review of literature and collection of data	Event based rainfall-runoff published data has been collected by three events for different sites. 22 storms data have been collected at three hours interval from Bree (1978) paper. 8 storms daily data have been collected from Diskin & Boneh (1975) paper. 4 storms data at 4 hour interval has been collected from K.P. Singh (1976) paper. Different sets of data has been used to develop different models.
IInd	Development and application of soft computing methods for rainfall-runoff modelling	Models are developed by Artificial Neural Fuzzy Inference System (ANFIS) - grid and cluster techniques, which identified suitable numbers of fuzzy if-then rules through proper partition of the input space. Two variables as rainfall, and time variation are considered as antecedent and runoff as consequence of the model. The input variables are fuzzified with trapmf, gbellmf or guassmf membership functions to develop the fuzzy rules.
IIIrd	Testing, evaluation,	Results using both methods has been compared

	and comparison with different methods	with observed values and conventional methods for all three events. Reliability and performance criteria has also been obtained to get optimum results. Once the models are developed , Apart from other UH and IUH methods, the soft computing techniques have been used for future forecast.
IVth	Writing of report and paper publication	in progress...

Expected outcome

1. A soft-computing techniques/procedure for event-based rainfall-runoff modeling.
2. Such a model developed for specific basin can be used for prediction and simulation of runoff due to other events or design future events.
3. The technique can be used as an alternative/supportive to the traditional unit hydrograph approach for event-based rainfall runoff modeling. The tested/trained response file can be used for analyzing runoff at the outlet of the same catchment for other events, while the same procedure needs to be repeated for other basins.

Adopters of the results of study

Research, field, and academic organizations and practitioners dealing with rainfall runoff in particular and water resources in general.

Deliverables

Technical report and research papers

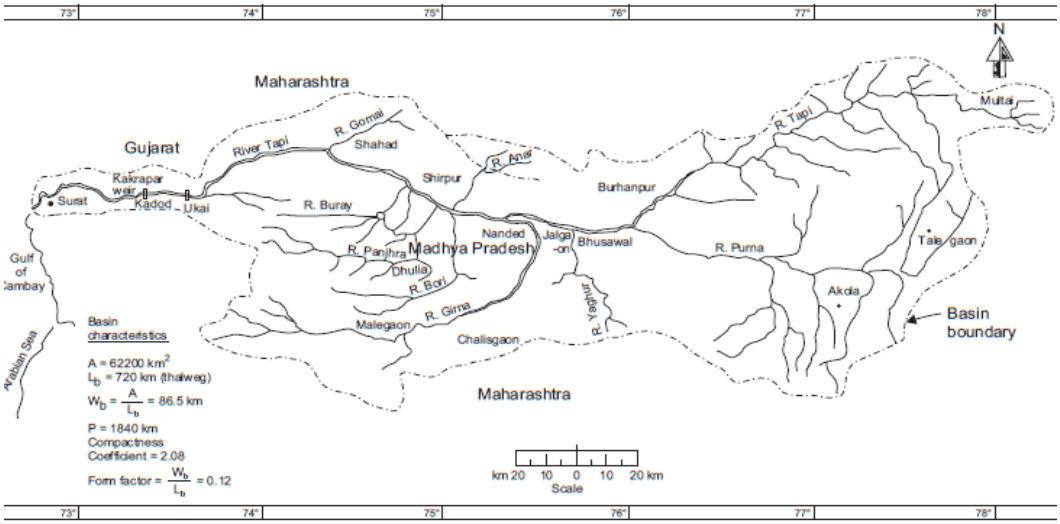
Study 3:

Title: Analysis of water management scenarios in Tapi River basin using MIKE Basin Software

Study group: PI: Rama Mehta
Co-PI: M.K. Goel
D.S. Rathore

Date of Start: April, 2010
Date of completion: March, 2013
Funded: internally

- Tapi basin boundary



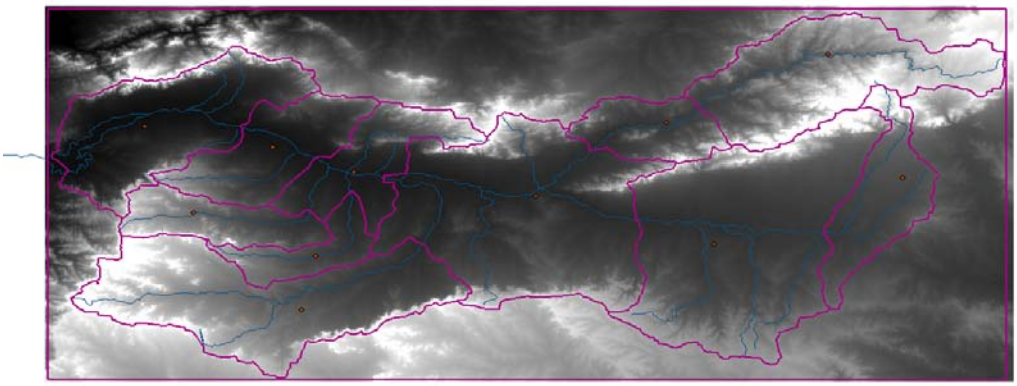
Objectives:

1. Identification of water resources issues in the study area.
2. Model setup for Tapi river basin upto Sarangkheda using Mike basin software.
3. Analysis of different water management scenarios.

Statement of the problem:

To develop the model for Tapi river basin for its better water management using Mike Basin Software.

Dem of Tapi basin



Action Plan:

Work	First year	Second year	Third year
1. Identification of water resources issues and other information in the study area. 2. Collection of hydrological and meteorological data for all sub-basins from concern states/ NTBO, 3. Study of model and its Input data files formats.	<…>		
1. Visit to NTBO office ,Surat to collect relative data for study. 2. Data files preparation (dfso input files) for all sub-basins in Tapi basin according to the Mike basin requirement. 3. Rainfall runoff modeling for each sub-basin using NAM model.		<……>	
1. Modeling for Tapi basin with all sub-basins outputs. 2. Analysis of different water management scenarios 3. report writing and paper publication			<…>

Action Taken:

Objectives (for the period April 2010-March 2011)	Achievements
1. Identification of water resources issues and other information in the study area.	1 Discharge upto Sarangkheda with outflow of large dams existing in Tapi basin is a big issue as there is a big flood in its downstream.
2. Collection of data for 11 sub-basins in whole Tapi basin from concern states/ NTBO.	2 Rainfall, discharge (for few sites), water level, and other hydrological information w.e.f. 1990 to 2010 for some areas as Dedtalai, Burhanpur, Lakhpuri, Yerli & Dapori etc. have been collected with concerned agencies. For other sites, only rainfall data is available. Operational data for Hatnur and Girna dams have been obtained from concerned divisions.
3. Study of the model for its input data.	3a. Input data as dfso files for each sub-basin is required for MIKE BASIN

	software. 3b. Collected data has been analyzed and used to prepare the input files as dfso files to run the software.

Objectives (for the period April 2011-March 2012)	**Achievements**
1. Rainfall runoff modeling for each sub-basin using NAM model. 2. Basin Analysis 3. Specific runoff of upstream and intermediate catchments. 4. Routing of the intermediate catchments	1. To complete the discharge series from rainfall data for few sites (where discharge was not available), Rainfall-Runoff modeling using NAM model has been done. 2. Tapi basin has been divided into 11 sub-basins. Total inflow and discharge have been collected at each sub-basin. 3. Specific runoff series of upstream and intermediate catchments have been obtained for further analysis. 4a. Routing models have been prepared for intermediate catchments- ❖ Dedtalai & Burhanpur…..Burhanpur ❖ Lekhpuri & Yerli …. Yerli ❖ Burhanpur, Yerli & Dapuri.. Savkheda ❖ Morane, Malkheda & Savkheda… Sarangkheda
5. Discharge at Sarankheda	4b. Routed flow series have been obtained with specific runoff. 4. 5. Discharge from all sub-basins i.e. Burhanpur, Yerli, & Savkheda upto Sarankheda has been computed

Objectives (for the period April 2012-March 2013)	Achievements
1. Analysis for different water management scenarios	• Basin has been divided into for sub basins as two big hydrological projects i.e. Hatnur dam and Girna dam are considered. • Reservoir operation has been done using Mike Basin for Hatnur and Girna reservoirs. • Rule curves have been devised for optimum operation. • Deficit for increasing demands for projected future population (2050)

2. Report writing and paper publication	have been considered. • Differentscenarios has been set for increasing demand with increasing population. • Discharge from sub basins has been calculated. In progress.....

Adopters of the results of the study and their feedback:

- NTBO, State Agencies: Maharashtra, Gujarat, & Madhya Pradesh

Deliverables:

- Research papers and technical report.

Data generated in the study:

- The hydrological and meteorological data has been collected from the concerned divisions of NTBO offices in M.P., Gujarat and Maharashtra. Data has been analyses and converted into dfso files for MIKE BASIN software.

Study benefits / Impacts:

- The results of this study will lead to better Management of water resources of Tapi River Basin.

Future Plan:

- This study can be extended upto Ukai dam in future.
- Knowledge of Mike basin software and its applications for Tapi basin for water management can be used for other river basins in India.

Study 4:

Title: Web GIS based snow cover information system for Himalaya (Research study)

Study group - Scientists:
D. S. Rathore, Sc F
Deepa Chalisgaonkar, Sc F
L.N. Thakural, Sc B
Scientific staff:
Tanvear Ahmad, PRA

Type of study - Internal
Natural of study - Hydrological information
Date of start - April 01, 2012
Duration and Scheduled date of completion - 1 year**,** 31st March 2013

Objective:

The objective of the study is to publish snow cover information on web/ intranet using GIS server for Himalaya.

Statement of the problem

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

Location map/study area

Himalaya range is selected for the study.

Approved action plan and timeline:

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

Recommendations / suggestions in previous WG

Recommendations	Action Taken
1. Dr. R.D. Deshpande suggested that the scope of the study may include other hydro meteorological data such as temperature and rainfall, relative Humidity etc. The data are already being collected in other ongoing studies and may be readily available. Further, information available from Indian	Hydrometeorological data namely Aphrodite rainfall data require permission which was not received as of now and are not included in the study. AWiFS data are included in study for part of the area. ETM+ data for a year (one date) were downloaded and processed for snow cover.

satellites may be included. Dr Kishor Kumar pointed out that fine resolution data may be included.	

Achievements

Year	Objectives	Achievements
2012	i) Download of data	AWiFS, MODIS, SRTM 250, ETM+ data were downloaded. AWiFS data were downloaded for part of the area.
	ii) Processing of the data	Data with NDSI>0.4 are classified as snow. Maps post processed, mosaiced and vectorized.
	iii) Preparation of Web GIS	Snow, sub basin map published as WFS layer
	iv) Report preparation	In progress

Deliverables:

Web service (WFS) for snow cover and hydrometeorology for Himalaya for year 2009.

Data procured and generated during the study:

Satellite data downloaded/ available

- AWiFS (March and November 2009, 2 scenes each for Uttarakhand)
- ETM+ data (Oct- Dec 2001)
- MODIS Terra Snow Cover, 8 day composite (March- September 2007, 500 m)
- SRTM 250

Data generated

Snow cover mosaic 2007, Oct- Dec 2001, 2009 (part of area), sub basins.

Users/ beneficiaries of the study

-Policy makers and planners, line departments

Study 5:

Title: Software for Frequency Analysis in Hydrology

Project Team: Deepa Chalisgaonkar
D S Rathore
S K Singh
M K Goel

Date of Start: April 1, 2012

Duration: 1 year

Funding: Internal

Objective:

The envisaged objective is to develop a menu driven, interactive software for frequency analysis of hydrological data using different distributions.

Methodology:

A menu driven, user-friendly software has been developed in Visual Basic language to carry out frequency analysis with different types of information. The software will provide a user-friendly and efficient environment that will be easy to use by water managers. Furthermore, the software will be built with a graphical user interface that requires little training for using it. The software will use a multitude of algorithms for data import, validation and analysis. It allows the handling of a multiple site project and the comparison of quantile estimates with or without historical information.

This software will help to calculate probability plotting positions, estimate the parameters of the various statistical distributions, evaluate the fit of these distributions, estimate flood quantiles, and compare estimates obtained with and without use of historical information. The software will compute the maximum likelihood estimates of probability distribution parameters for several statistical distributions used in flood frequency analysis.

It is a user friendly tool that can be used by practitioners for solving frequency analysis problems in the field of hydrology.

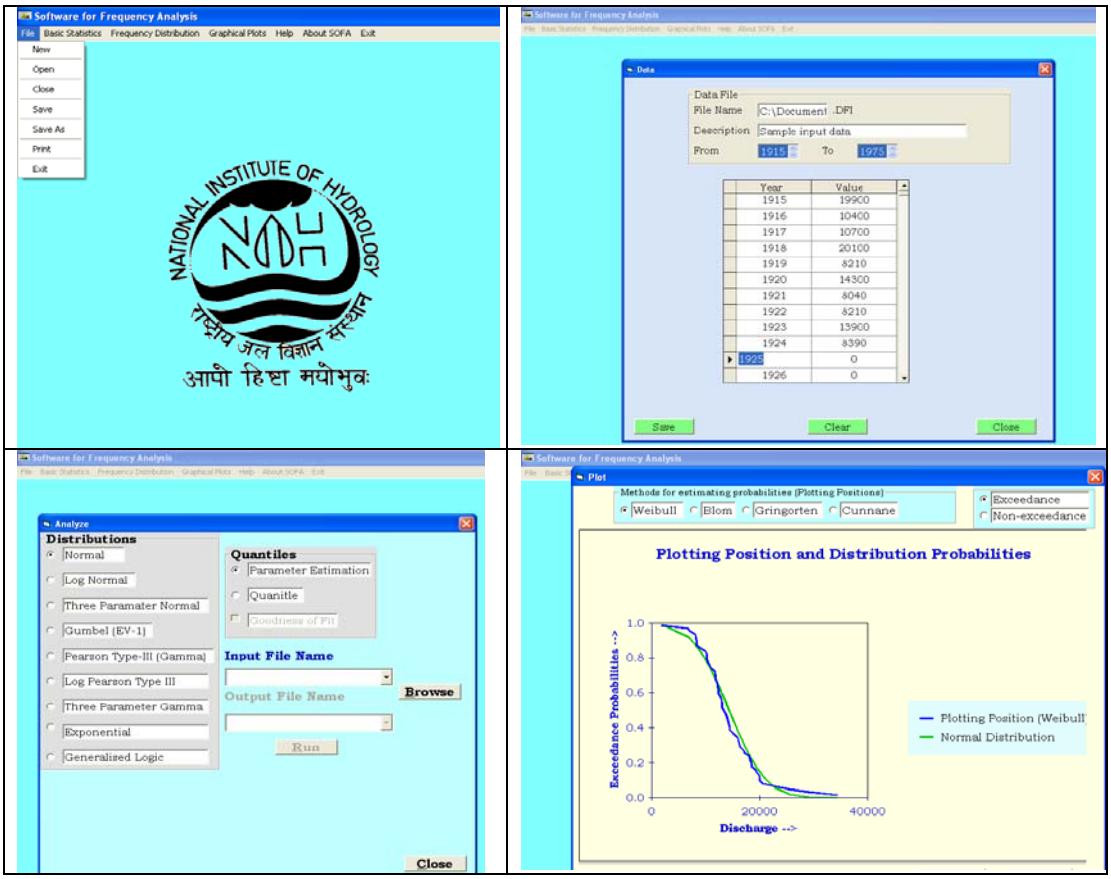
Achievement:

Objectives (April 2012 – till date)	Achievements
1. Review of existing softwares	1. Downloaded software from frequency analysis of hydrological data like Hyfran, HEC-SSP, Rainbow etc were downloaded and their features were explored.
2. Design and Development of the framework of the software	2. Done
3. Development of module for data entry and updation.	3. Done

4 Development of module for graphical representation 5. Development o 'Help' module 6. Development of package	4. Done alone with option for copy and printing of graph 5. The coding has been done and final editing in process. 6. Done

Results:

Some of the screens shots for frequency analysis using 'Normal Distribution' are shown below:



The software has been developed on the similar lines for other distributions.

Data generated in the study:

This work is related to software development. Hence no data is being generated.

Adopters of the study and study benefits:
It will be a user friendly tool that can be used by practitioners for solving frequency analysis problems in the field of hydrology.

Deliverables:

Research papers and reports.

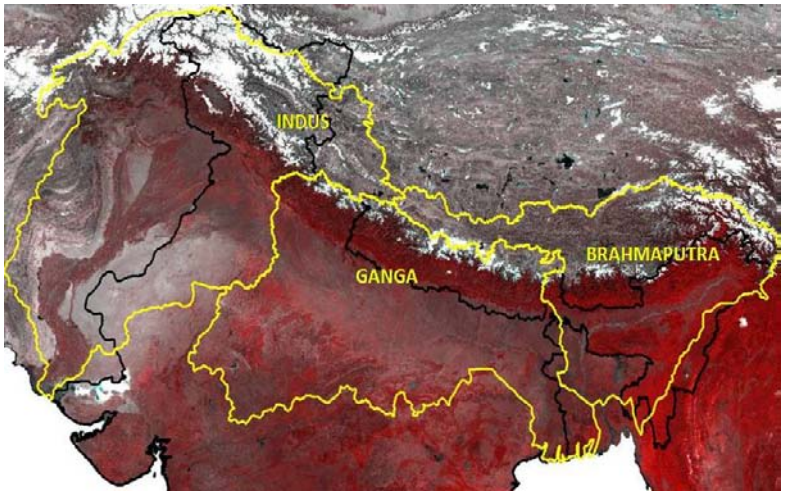
Study 6:

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

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

Location/Study area:

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



Objectives of the study:

The objectives of the study are:

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

Statement of the problem:

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

Methodology:

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

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

Approved action plan and timeline:

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

Achievements:

Year	Objectives (period October-March 2013)	Achievements
2012-13	Analysis for Central Himalayas	• The hydrometereological data in the central Himalayas has been analyzed for temporal and spatial characteristics of the temperature. • The parametric approach has been used to find out the trend in temperature and rainfall time series. • The non-parametric approach has been used to detect trends in temperature and rainfall series.

Recommendations / suggestions in previous WG:

Recommendations	Action Taken
No specific comments were made during the previous working group	

Analysis and Results:

The climate change variability and trend of mean annual temperature in central Himalayas have been carried out for the observational sites Mukteshwar, Mukhim and Dehradun situated at different altitude in the central Himalaya region. These sites are situated at an altitude of 2311m, 1945m and 682 m respectively.

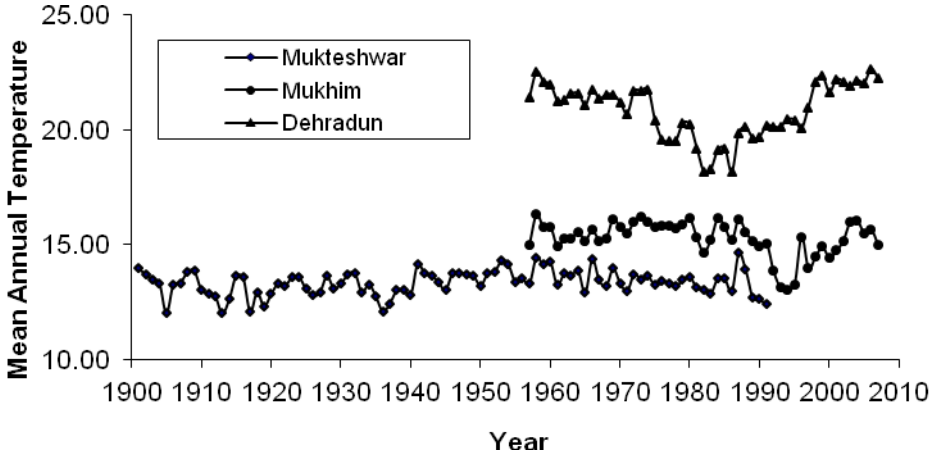


Fig: 1 Annual mean temperature at different sites in central Himalayas

The availability of the mean annual temperature (for different record period) at these observational are shown in Fig.1 with 91 year data at Mukteshwar and 51 year data at Mukhim and Dehradun. The anomalies (deviation from long term average) of the

mean annual temperature at these sites were evaluated to determine the average linear trends at these sites during the above periods. The study indicates increasing trend in mean annual temperature at Mukteshwar, whereas Mukhim and Dehradun show decreasing trend in the mean annual temperature. It is found that the average rate of increase at Mukteshwar is 0.004 ^{0}C/year whereas it is -0.019 ^{0}C, -0.001 ^{0}C at Mukhim and Dehradun respectively. The temporal and spatial pattern of variability at different sites in the central Himalayas may provide useful insights for the long term planning and management of water resources in the region.

Adopters of the results of the study:

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

Deliverables:

Research papers and reports

Major items of equipments procured:

Nil.

Lab facilities used during the study:

GIS software, ERDAS Imagine and ARCGIS and Microsoft office.

Data procured and generated during the study:

Rainfall and Temperature data collected from various sources:

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

Study benefits/impacts:

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

SPONSORED RESEARCH STUDIES

Study 1:

a. Title: Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin

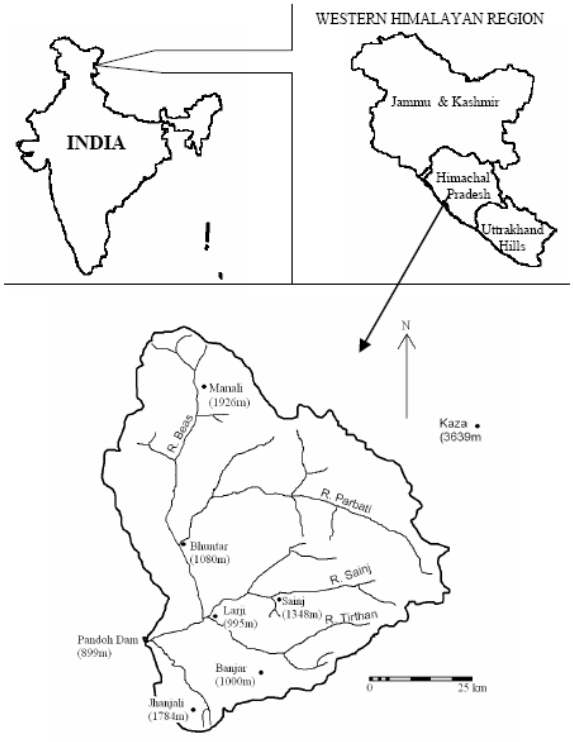
b. Study Group: Dr. Sanjay K. Jain,
Dr. S. P. Rai,
Mr. L N Thakural

c. Date of Start: 1st April 2009

d. Schedule date of completion: March 2012 (Extension up to December 2013)

e. Type of study: PDS under HP II

f. Location map / Study area



g. Objectives:

1. To create spatial data (consisting of snow cover area and DEM) and meteorological/hydrological data base for the study area
2. To estimate snow cover area and its temporal variation using remote sensing data.

3. To estimate snow melt runoff in Beas River at Pandoh dam.
4. To study the composition of stable isotopes $\delta^{18}O/\delta D$ in the winter snow, summer rainfall, ice core and meltwater and separate snow, rain and glacier melt components in the river flow.
5. To study trend of precipitation, temperature and stream flow in Beas basin using parametric and non parametric approaches, and
6. To investigate the impact of likely future changes in climate on stream flow in the study area using GCM/RCM based scenarios.

h. Statement of the problem:

This study is being carried out under HPII. The simulation of snowmelt runoff will be carried out using remote sensing data and hydrological model. The field samples will be analysed in Nuclear Hydrology Lab. For separation of runoff into snow/glacier melt runoff. Impact of climate change on stream flow will be studied with the help of future scenarios.

i. Approved action plan: Work plan approved for four year is as follows:

Activity	Year 1	Year 2	Year 3	Year 4
Reconnaissance surveys, Data collection				
Problem conceptualization				
Meetings with participating agency				
Appointment of project staff				
Procurement of data, equipment, software, consultancy				
Database development				
Field visits for sample collection				
Applications of conceptual model				
Model calibration & Validation				
Development of climate change scenarios and impact studies				
Report writing				

j. Achievements

Year	Objectives (for the period April 2010 - March 2011)	Achievements
2010-11	i) Analysis of data and trend analysis ii) Creation of data base in GIS iii) Simulation of snowmelt runoff model iv) Generation of climate change scenarios v) Samples collection from the field vi) Analysis of samples vii) Simulation under changed scenarios	Achieved Achieved Achieved Achieved Achieved Under progress Under progress

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

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

l. Analysis and Results:

Trend analysis of rainfall, runoff and temperature has been carried out using regression analysis, ManKendall and Sen's Slope. As per this analysis, temperature at Bhunter and Largi is showing increasing trend and rainfall at all the station except one shows decreasing trend. The snows cover area for the years 2000-2009 have been prepared from MODIS data. IRS WiFS and AWiFS data have been collected from NRSC, Hyderabad and snow cover maps have prepared. The model is applied at two more sites i.e. at Manali and Bhunter. Simulation of stream flow has been carried out at three stations i.e. Manali, Bhunter and Pandoh. To see the impact of climate change, hypothetical scenarios were applied earlier. The work of generation of future of climate scenarios (consultancy work) was awarded to IISc., Bangalore. The report has been received from IIsc. Banglore and results have been discussed during the visit made in June 2012. The simulation under future scenarios is under progress and results will be presented during the meeting.

For carrying out isotopic analysis, samples have been collected from a number of sites. Daily and weekly samples have been collected from all the sites for the period April 2011 to October 2012. A field visit has been made during November 2012. Analysis of these samples is under progress and results will be presented during the meeting.

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

Bhakra Beas Management Board

n. Deliverables

Reports and research papers

o. Data generated in the study

Snow cover maps from satellite data. Samples collected from the field, stream flow hydrographs etc.

Study 2:

a) Title: Assessment of Effects of Sedimentation on the Capacity/ Life of Bhakra Reservoir (Gobind Sagar) on River Satluj and Pong Reservoir on River Beas

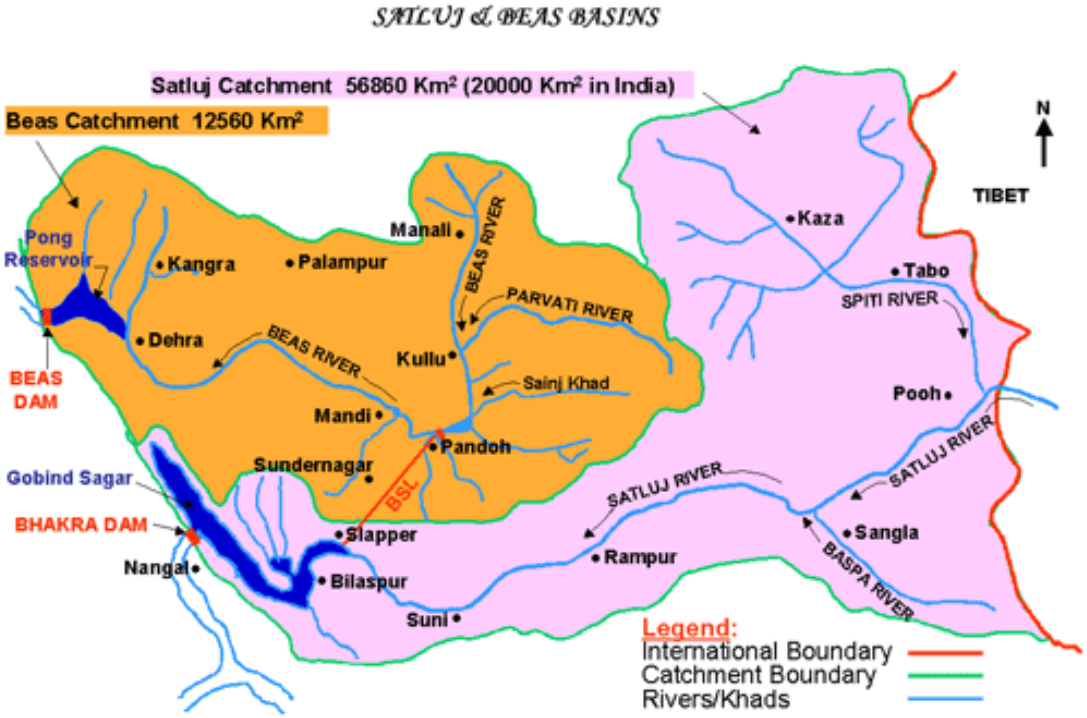
b) Study Group: Dr. Sanjay K. Jain,
Dr. J.V.Tyagi,
Dr. Rama Mehta

c) Date of Start: 1st April 2009

d) Schedule date of completion: March 2012 (Extension up to June 2013)

e) Type of study: PDS under HP II

f) **Location map / Study area:**



g) Objectives:

The objectives of the study are as follows:

- Collection and development of data for the catchment and the reservoir by latest techniques.
- Analysis of existing sediment data at various locations in the catchments of river Satluj and Beas.
- Soil erosion modelling for both the catchments
- Development of mathematical model for instant study of Sedimentation to assess life of reservoirs.
- Dissemination of knowledge, findings and applications of the developed models to field Engineers through preparation of manual, leaflets & by organizing workshop & seminars.

h) Statement of the problem:

This Purpose Driven Study (PDS) has been taken up by BBMB. They have requested NIH for collaboration in this study. Therefore this study has been proposed under the work program of the division. BBMB has already informed about the approval of chairman, BBMB for partnership of NIH in the study.

i) Approved action plan

Creation of database

- Topographical maps of catchments of Satluj and Beas preferably the scale of 1:250000/1:50000 for drainage, contour etc. BBMB
- Conversion of catchments map into Digital map. NIH
- Landuse map using Remote Sensing data. NIH
- Soil map of the catchments. BBMB
- Digital Elevation Model (DEM) of the catchments. NIH
- Pre – impoundment and the latest observed cross- sections of Bhakra and Pong reservoir etc. BBMB
- Database comprising of rain-fall, discharge, sediments analysis for various existing sites located in Bhakra & Pong Catchments. BBMB

Assessment of sedimenation rate

- Sedimentation assessment by remote sensing NIH
- Sedimentation assessment by hydrographic survey BBMB

Modelling of soil erosion/sediment yield

- Sediment discharge relationship NIH/BBMB
- Modelling of soil erosion/sediment yield NIH

j) Achievements

Year	Objectives (for the period April 2010 - March 2011)	Achievements
2010-11	i) Analysis of data and sediment rating curves ii) Creation of data base in GIS iii) Processing of satellite data iv) Assessment of sediment rate v) Modeling of sediment yield vi) Report writing under progress	Achieved Achieved Achieved Achieved Achieved Under progress

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

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

l) Analysis and Results:

Processing of satellite data has been completed. Sedimentation rate using remote sensing data have been completed. Sediment discharge relationships for Satluj basin on the basis of regression analysis, sediment transport models and soft computing techniques like ANFIS and ANN have been deployed. Discharge data are used as input data and sediment yield as output data for entire study. Reservoir sedimentation study for both the reservoirs using remote sensing have been completed.

Land use map, soil map and DEM etc. of both the catchments have been converted into Arc SWAT format for sediment yield modeling. Simulation using ArcSWAT have been carried out for both the basins. The results of ArcSWAT have been obtained for both the basins. The progress will be presented in the meeting. The report writing is under progress.

m) Adopters of the results of the study and their feedback

Bhakra Beas Management Board

n) Deliverables

Reports and research papers

o) Data generated in the study

Landuse, DEM, soil etc. maps from satellite data/ancillary data, sedimentation rate from two reservoirs, and sediment yield map from two catchments.

Study 3:

Title: Hydrological Assessment of Ungauged Catchments (Small Catchment)

Project Cost (NIH Component): 67.5 LAKHS (Under HP2)
Name(s) of Principal Investigator(s):

PI: Pradeep Kumar Bhunya, Scientist-D
Co-PI: (i) Dr. Rakesh Kumar, Sc. F, Head (Surface Water Div.),
(ii) Dr. Sanjay Kumar (Sc. D, Surface Water Div),

Investigator: D S Rathore (Sc. F, WRS Div.),
Dr. P. C. Nayak (Sc. D, RC Kakinada)

Study Area: Mahanadi basin, Orissa
Time Duration (for which progress is indicated): 2009-2013

PROGRESS OF THE PROJECT

On basis of the detailed study and analyzing the results of other organizations working on this area in the region, a standardized design practice is to be developed for the ungauged catchments in the region. The following are the outcome from the project.

1. Hydrological i.e. stage and discharge data for 14 GD sites were from CWC and another six GD sites (annual time scale) from water resources department, Bhubaneswar. Geomorphological basin characteristic were collected from toposheets and RS imageries. A few field trip has been taken up by project staffs during this period for data measurement using current meter and raingauges that have been procured under HP2. About 22 small catchments (Br-sites) were collected from earlier technical reports/projects from NIH library.
2. Unit hydrographs have been derived for eleven catchments in the region as per date availability status. Six methods is followed for this work viz. Clark, Nash, Snyder, SCS, and GIUH methods. Lat three were for ungauged basins and geomorphological basin characteristics is used for UH computation. These estimated parameters are used for deriving regional UH. Regional unit hydrograph relationships for the region have been developed using data from fourteen catchments (with long term data collected from CWC and Orissa water resources department) . In addition to conventional, and a few methods like Clark, Nash, used the catchment characteristics of ungauged catchment in the region from the available topographical sheet and remote sensing imagery data, the UH for that catchment was derived using GIUH and synthetic methods. This shall provide the user to opt among five methods (Snyder, SCS, Gamma, Beta and Weibull method) and the methods to estimate UH parameters like time to peak and peak flow form geo morphological data.
3. Recommend a standard statistical distribution procedure for homogeneity tests.
4. Regional formulae to be used for ungauged catchment in the region to estimate peak flood and time to peak for different storms. The formulae shall be derived with latest data and shall also provide the uncertainty (with risk and reliability degree).

5. Recommend a standard flood frequency models with robust (and least biased) distributions for the different regions in Mahanadi zone. This may be recommended for at-site analysis for return period floods.
6. Recommend a regional flood formulae for the different small catchments (and 13 catchments with records as outflow in CWC gauge sites) and regions in Mahanadi zone.
7. Recommend a standard POT method for return period flood computation when the annual maximum series is short.
8. Rating curve (a relationship between stage and discharge) at 13 GD sites have been developed for the region.
9. Studied in detail the regional flow duration curve using data from 14 GD sites and recommended a regional flow duration curve to estimate the dependable flows for the ungauged catchment.
10. Completed a chapter on estimation of confidence intervals and uncertainty of predictions
11. Completed a chapter on fundamentals of remote sensing and its application in hydrology

To be submitted during March 2013.

Study 4:

Title: Preparation of Ganga River Basin Environment Management Plan (GRBEMP)

Project Cost (NIH Component): 12.0 Lakhs + Service tax

Name(s) of Principal Investigator(s):

1. Dr Sharad K Jain, Scientist F (PI)
2. Dr N C Ghosh, Scientist F
3. Dr Sanjay K Jain, Scientist F
4. Dr M K Goel, Scientist F

Objectives

The GRBEMP project has been awarded by the MoEF to a consortium of 7 IITs; some other institutes and individuals are associated with the work. The objectives of the work to be carried out at NIH are:

1. Studies based on statistical analysis of the past data to get an indication of the hydrology and flow regimes. River stretch up to Allahabad could be considered on priority. For this three segments need to be studied. First river Ganga up to Rishikesh, second river Ganga between Rishikesh and Triveni Sangam and the third Yamuna up to Triveni Sangam.
2. Hydrologic modelling of the Ganga basin using the SWAT model in association with the WRM group of GRBEMP.

Time

The duration of the study will be the same as the main GRBEMP project, i.e., t ill Sep. 2013.

Status

1. Based on the onserved flwo data, characterization of the hydrology of the Upper Ganga basin up to Dev Prayag is in progress.

2. SWAT model has been set up for the Alaknanda and Bhagirathi rivers. Model calibration is in progress.
3. Work has also been initiated to identify the reaches of Ganga where the river is influenct and effulent between Haridwar to Narora.

NEW RESEARCH STUDIES

Study 1:

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

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

Objective of the study:

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

Brief Description of Model:

Effective management of water and related environment in a river basin requires an integrated and co-ordinated planning within the basin. In the present approach of water availability estimation in a river basin, it is difficult to account for the effect of various developmental activities and climate sensitive parameters on the water resources scenario in a river basin. Groundwater is not given enough attention in the assessment of total water resources in the basin and the water requirement for different purposes is not precisely estimated. Discharge is considered as the basic unit for water availability estimations which may be affected by a number of basin parameters and developmental activities.

With this need in view, 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 basin is divided into grids of uniform size (~ 1 km) and model computes various components of hydrologic cycle such as actual evapo-transpiration, overland flow, groundwater recharge, and residual soil water content at monthly time step for each grid. The model brings out total water availability in the basin; water consumed by different uses; and water storage in different hydraulic structures, in soil water zone,

and in groundwater aquifer in a river basin. By taking repeated runs of the model for longer time periods, sustainability of various water resources management plans can be examined. The model can be used to: a) visualize the effect of land use change, cropping pattern change, climate change (in terms of rainfall and its distribution, temperature, humidity etc.), and population and industrial growth on the basin water resources, and b) analyze various management options like inter-basin transfer of water, development of new water resources projects etc.

The model 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) routing of overland and channel flow. Groundwater modeling aspects at the scale of river basins are a difficult task and it is proposed to provide option for some simplified representation of groundwater consideration.

It is proposed to prepare the input data files in the form of user-interactive forms, as has been done for NIH_ReSyP software.

Adopters of the study and study benefits:

This study can be used for hydrological modeling for river basin planning and visualize the impact of various factors (natural or anthropogenic) on the water resources of a river basin.

Deliverables:

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

Study 2:

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

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

Duration: Two years. (April 2013-April 2015)
Funding: Internal

Objectives

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

Brief methodology

In this study the annual maximum peak flood series of about 50 years shall be employed for about 47 gauging sites viz: (a) 23 Bridge catchments (1957-1990) and (b) 14 GD sites maintained by CWC (1978-2009) of Mahanadi region. The first phase shall index the climate scenarios using General Circulation Model for the region. In second phase, the flood estimates for various return periods for the original series shall be analyzed in two scenarios: in first case the highest 10 % values of the annual peak flood have to be increased by a certain percent (depending on mean rate of AMS over 10 years cycle) and in second case the lowest 20% values of the annual peak flood have to be decreased by a certain percent. The proposed approach is to separate the non-stationary pooled quantile function into a local time-dependent component, comprising the location and scale distribution parameters and estimation of trend magnitudes in the location and scale parameters of a non-stationary series. The trend change in various return periods in three phases: 1957-1987, 1980-1995, 1990-2011 shall be co-varied with land use index (using normalized difference vegetation index or weighted CN whichever is available). The study shall analyze the variation of percentage change of these above cases in temporal scale that with time.

Deliverables

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

Study 3:

Title of study: Web GIS based snow cover information system for Himalaya

Study group - D. S. Rathore, Sc F, PI
Deepa Chalisgaonkar, Sc F, Co-PI
L.N. Thakural, Sc B, Co-PI
Tanvear Ahmad, PRA
Type of study - Internal
Natural of study - Hydrological information
Date of start - April 01, 2013
Scheduled date of completion - 31st March 2015
Duration of the study - 2 years

Objective:

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

Statement of the problem

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

End users/ beneficiaries of the study -

Policy makers and planners, line departments

Whether study is a new study/ extension of previous studies -

During 2012- 2013, a study entitled 'WebGIS based snow cover information system for Himalaya' was carried out. The study utilized Geoserver Web GIS software and published selected data for year 2007. It is proposed to publish more snow cover data in this study.

Baseline data/ information on the study area and results of previous studies -

MODIS satellite data are available from internet for Himalaya. Sub basin maps extracted from SRTM DEM are available.

Methodology

1. MODIS data will be downloaded from internet and processed for snow cover.

2. The snow cover maps will be published as web service (WFS) on web using Geoserver Web GIS software.

Timeline - Quarter-wise work programme (2013-14, 2014-15)

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

Deliverables:

Web service (WFS) for snow cover of Himalaya

Proposed measurable indicator: None

Involvement of end users/ beneficiaries: None

Specific linkage with institution and /or other NGOs: None

Major items of equipment needed: None

Study 4:

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

Study Group - D. Chalisgaonkar, Sc-F
S. K. Jain, Sc-F
Prabhash K. Mishra, Sc-B

Type of Study - Internal

Start Date - April 01, 2013

Scheduled date of completion- 31st March, 2015

Background and Concept:

The idea of considering water use along supply chains has gained interest after the introduction of the 'water footprint' concept by Hoekstra in 2002. The water footprint is an indicator of freshwater use that looks not only at direct water use of a consumer or producer, but also at the indirect water use. The water footprint can be regarded as a comprehensive indicator of freshwater resources appropriation, next to the traditional and restricted measure of water withdrawal. The water footprint of a product is the volume of freshwater used to produce the product, measured over the full supply chain. It is a multidimensional indicator, showing water consumption volumes by source and polluted volumes by type of pollution; all components of a total water foot print are specified geographically and temporally.

The concept of the water footprint has been developed to create an indicator of water use in relation to the consumption by people. The water footprint of a country is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of the country. The water footprint is divided into a blue, a green and a gray component. The blue component refers to the evaporation of groundwater and surface water during the production of a commodity, the green component to the evaporation of rain water for crop growth, and the gray component to the water required to dilute the water pollution that is caused by the production of the commodity to acceptable levels.

In the next fifty years, India is projected to face the challenge of feeding a population of 1.6 billion people with a higher level of welfare than at present. The current view of the Indian government on food security is to hold on to the goal of food self sufficiency. Knowing that agriculture is the main consumer of water, the implied increase in food demand will increase the pressure on the renewable water resources.

The New Delhi – the National Capital Territory (NCT) of India, a metropolitan cities with a population of 1.67 crore (Census, 2011) is the second largest populous cities in India. The population density in the city is much higher than in any other city in India (11000/ km^2). It's no secret that Delhi has no additional sources of water and in the next few years the city could be facing a major water crisis. Growing urbanization, improvements in living standards, exploding population are just some of the contributing factors. Delhi Jal Board (DJB) officials accept that there are huge variations in supply, primarily due to the population expanding at a rate that was never factored in plans.

The Water Footprint is a fresh concept for proper assessment of different water use viz. agriculture; domestic; industrial; energy, etc. Looking at the increasing skewed supply and demand of the water resources in the region, this study has been proposed to make an assessment of the Water Footprint of the NCT region, which only help the decision makers and government bodies in making timely intervention.

Objectives:

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

- To quantify the different components of water footprint i.e. Blue; Green, & Gray components of the NCT region;

- To assess the international and interstate virtual water flows from and to the NCT region to establish the virtual water balance;

- To analyze past-present-future water footprint of the NCT region for making realistic water management plan;

Brief Methodology:

'Water footprint assessment' refers to the full range of activities to:

(i) Quantify and locate the water footprint of a process, product, producer or consumer or to quantify in space and time the water footprint in a specified geographic area;
(ii) Assess the environmental, social and economic sustainability of this water footprint; and
(iii) Formulate a response strategy. The goal of assessing water footprints is to analyze how human activities or specific products relate to issues of water scarcity and pollution, and to see how activities and products can become more sustainable from a water perspective.

A full water footprint assessment consists of four distinct phases (Fig. 1):

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

To accomplish the study, following assessment will be done as given below:

- Crop water requirement;
- Dilution water requirement;
- Green crop water requirement;
- Blue crop water requirement;
- Virtual water contribution;

- Water productivity
- Water use, etc.

Data requirement:

Water footprint assessment for a region requires huge data. The study will assess the land use land cover in the region using remote sensing data, and also in preparation of other thematic maps for quality interpretation for water management plan. Both primary and secondary data from different sources involving line departments will be explored to derive the water footprint. Following are the major data/ map which need to be collected to accomplish the study.

i. Index map, Soil map, Irrigation map
ii. Area and Population including livestock
    a. Residents
    b. Floating
    c. Crop data Crop type, Crop production and productivity, Crop evapotranspiration, crop coefficients
    d. Water use data Domestic, Industrial, Agriculture/ Irrigation, Energy
    e. Climatic data Rainfall, Temperature, Humidity, Sunshine
    f. Commercial Trade data International, Interstate
iii. Other data
    a. Industrial processes
    b. Fertilizer and pesticide use

Deliverables:

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

Study 5:

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

Study Group - Shri P. K. Mishra
Dr. Sharad K. Jain, Sc "F"
Dr. Sanjay K. Jain, Sc "F"
Type of Study - Internal
Start Date - April 01, 2013

Proposed date of completion - 31st March, 2015

Study objectives:

The proposed study envisages assessing the climate change effects in KBK region, Odisha which is regularly facing drought, water scarcity, and flood as well. The study will focus on the following major objectives:

1. To analyze long-term historical climatic data to determine trend
2. To analyze the future climate in the region based on downscaled GCM data
3. To assess the current potential and utilization gap of water resources in the region to develop management plan

Study area:

The Kalahandi-Koraput-Bolangir (KBK) is three individual district administrations in the state of Odisha. During 1992-93, the three districts were reorganized into eight districts viz. Malkangiri, Nabarangpur, Rayagada, Nuapada, Sonepur, Kalahandi, Koraput and Bolangir. These eight districts comprise of 14 Subdivisions, 37 Tehsils, 80 CD Blocks, 1,437 Gram Panchayats and 12,293 villages. The eight districts which form the KBK region account for 19.72% population occupy over 30.59% geographical area of the State (155820 Km^2).

The KBK region is unfortunately famous for every poverty indices set forth by different study groups. The region though witnesses an annual rainfall of 956-1375 mm spread over four monsoon months viz. June, July, August and September, periodically facing drought in every 3-4 years. The climate in the area is sub-humid, dry with extreme summer and winter. The population in the region is a mixed group dominated by tribal. The area is endowed with mineral dominated natural resources and Non-Timber Forest Produce (NTFP) in the large encompasses of forest. Rain-fed agriculture is the principal occupation of the inhabitants.

Background of the study:

A study on Drought was carried out for Kalahandi district in Orissa (presently, Odisha) in the institute a few years back. This particular district along with two nearby districts i.e. Bolangir & Koraput are very much drought prone and have more or less similar climatic conditions.

A lot of changes have taken place in the region in the last few decades. Large-scale watershed management activities are also going on funded by NABARD and other Commercial Banks. Development of KBK region is one of the most priority areas for State govternement also. Thereby, if a holistic study is taken for this region covering three districts will be more justified. Keeping in view these facts, the present study has been envisaged to study the water resources problem considering climate change and land use change occurring in the study region.

Brief Methodology:

In addition to the creation of a large database in GIS collected from primary and secondary sources including Remote sensing, the study commences with findings standard statistical characteristics for rainfall and temperature such as mean (μ), standard deviation (σ), skewness (S_k), kurtosis (K_k), and coefficient of variation (C_v) 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 will be analyzed for detecting trend utilizing parametric (5-year moving average) and non-parametric tests (**Mann-Kendall test**; **Sen's slope estimator**). CUSUM test will be utilized the most probable year where the rainfall and temperature trend has been shifted considerably. 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.

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 3.75^0 latitude x 3.75^0 longitude grid-scale (http://www.cics.uvic.ca/scenarios/sdsm/select.cgi) will be 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. Others climatic GCM model will also be explored during the study using soft computational techniques such as ANN.

Adopters of the study and study benefits:

This study can be used as a linkage for the past-present-future climate in the region, for interpreting water resources scenario in the context of climate change. The study will be of significant help to the district and state administration, NGOs working in the area, funding agencies (national and international) and policy makers associated in the field of water resources.

Deliverables:

A well compiled research report based on scientific investigation of primary as well as secondary data highlighting water resources scenario in the region considering climate change.

RESEARCH MANAGEMENT AND OUTREACH DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. V C Goyal	Scientist F & Head
2	Sri Omkar Singh	Scientist E
3	Dr. R V Kale	Scientist B
4	Sri Subhash Kichlu	PRA
5	Sri Rajesh Agarwal	RA

NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्ठा मयोभुवः

WORK PROGRAMME FOR THE YEAR 2012-2013

SN	Study	Team	Duration
	Internal Studies		
1	Recession Flow Analysis for Evaluation of Spring Flow in Indian Catchments	Ravindra V Kale (PI) V C Goyal	DOS: Apr 2011 DOC: Mar 2013
2	Understanding Water Use Efficiency: A Field Based Research and Documentation of Best Practices on Water Use Efficiency and Conservation	**Joint study** **I. NIH:** V C Goyal (PI) Subhash Kichlu Rajesh Agrawal **II. Indian Environment Law Offices, Gurgaon:** Ms Archana Vaidya Ms Shilpa Chohan Mr Shawahiq Siddiqui (PI)	Deferred
3	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs	**Joint study** **NIH HQs:** V C Goyal (Leader) Ravindra V. Kale New Scientist **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu, RC-Kakinada, RC-Sagar, CFMS-Guwahati, CFMS-Patna	DOS: Apr 2012 DOC: Mar 2015

PROPOSED WORK PROGRAMME FOR THE YEAR 2013-2014

SN	Study	Team	Duration
	Internal Studies		
1	Recession Flow Analysis for Evaluation of Spring Flow in Indian Catchments	Ravindra V Kale (PI) V C Goyal	DOS: Apr 2011 DOC: Oct 2013
2	Pilot Basin Studies (PBS) at six identified sites, jointly with the RCs and CFMSs	**Joint study** **NIH HQs:** V C Goyal (Leader) Omkar Singh Ravindra V. Kale **NIH RCs/CFMSs:** RC-Belgaum, RC-Jammu RC-Kakinada, RC-Bhopal CFMS-Guwahati, CFMS-Patna	DOS: Apr 2012 DOC: Mar 2015
3.	Action Research for Water Conservation and Management in Selected Village (s) in Hardwar District (Uttarakhand)	Omkar Singh, V.C. Goyal and C.K. Jain	DOS: Apr 2013 DOC: Mar 2015

WORK PROGRAMME FOR THE YEAR 2013-14

1. **Title of the study**:

   Recession Flow Analysis for Evaluation of Spring Flow in Himalayan Region, India (**Continuing Study**)

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

   PI : **:** Dr. R. V. Kale, Sc B, RMOD
   Co-PI **:** Dr. V. C. Goyal, Sc F and Head, RMOD

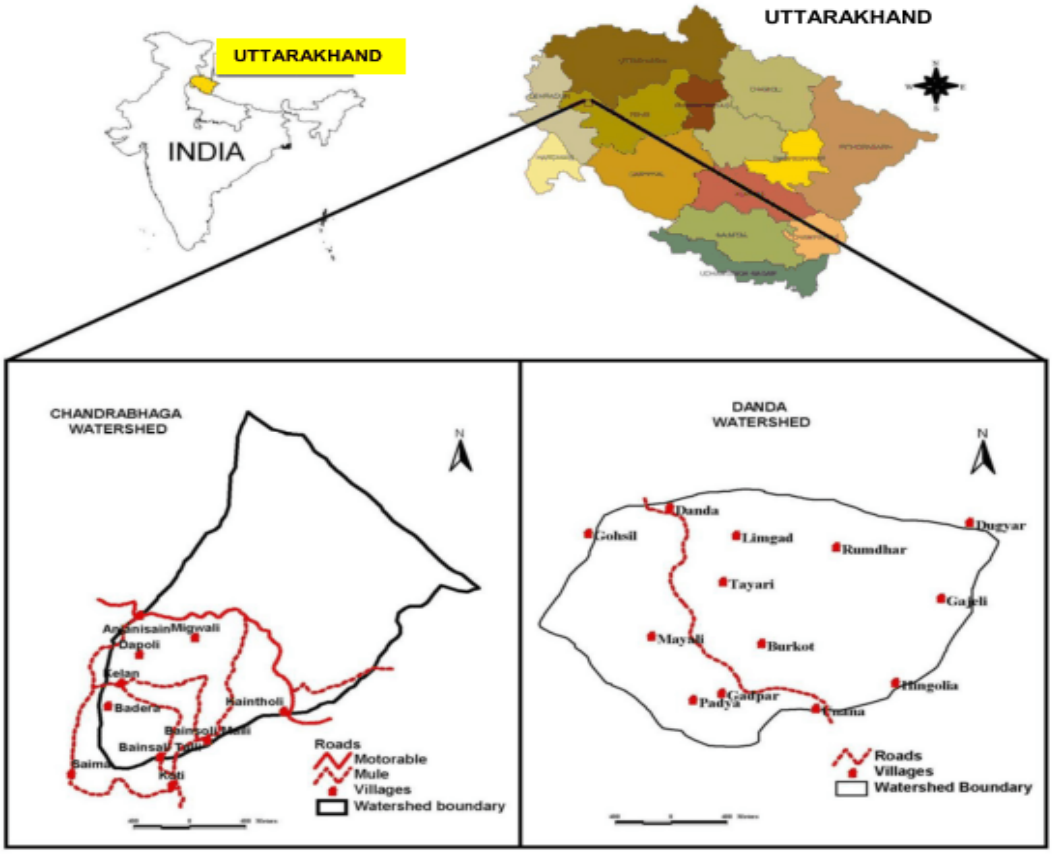
3. **Type of study**

   Internal (NIH funded)

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

5. **Scheduled date of completion:** October 2013

6. **Location map:** The study is being carried out for two small watersheds in the State of Uttarakhand, India. In these Himalayan watersheds number of springs found which are reliable sources of, clean water supply for drinking and domestic use. The geographical location of these watersheds is shown in following map:



7. **Study objectives**

   I. To develop a technique to assess the reliability of the spring flow as a

sustainable source of drinking and domestic water by analyzing the flow characteristics

II. To assess the potential for springs development as a water source

8. **Statement of the problem**

Springs in the Himalayas, in the Western Ghats and other places in India are the main source of drinking water due to logistical difficulty in creating storage for water. In such areas, majority of spring are of small orders which become dry during summer months. Flow/discharges in such springs vary considerably depending on the catchment characteristics (e.g. area, hydrogeology) and recharge in the catchment. The knowledge about the number of springs as well as their flow characteristics is important in the sustainable development of the water resources of these areas. The study of spring flow analysis has relevance to the water supply to rural areas, specifically hilly areas. As in many locations, rural development agencies would like to develop water resources of the catchment but lack the necessary hydraulic information. Further, the measurement and prediction of spring flows in aquifers are critical to water resources managers to maintain preferred flows based on the effect that current and projected ground water withdrawals have on water levels. Subsequently, the assessment of spring flow using physically based model requires the knowledge of fundamental input parameters such as hydraulic conductivity, specific yield and effective hydraulic conductivity describing the subsurface hydrology which are most problematic to obtain. Since well-drilling to estimate hydraulic parameters is often prohibitively expensive in developing countries, recession flow analysis is a very cost-effective and accurate alternative.

9. **Approved action plan**

Action plan: The collected spring flow and rainfall data will be analyzed for continuity and consistency of the record. In next step, a model will be formulated and will be tested for its accuracy. Then, formulated model will be used for the recession spring flow analysis. The results of the analysis will be produced in the form of research publication, technical report and user manual for field organisations.

Time-line and justification for time over runs:

Period	Task to be completed
April, 2011 – Sep. 2011	Review of literature and collection and preprocessing of data
15th Sep, 2011 – 14th March, 2012	Model formulation
15th March, 2012 – 15th March, 2013	Data analysis, results preparation and report preparation

April, 2013- September, 2013	Incorporation of topographic module to estimate morphological parameters of the spring watersheds using RS and GIS with hydrological module to arrive at aquifer hydraulic parameters and study report completion. During last meeting, this objective is undertaken as an extended part of originally decided study. We have received topographical/spatial data in January, 2013 and presently analyzing this data in RS and GIS environment to obtain morphological parameters and use it to estimate spring aquifer parameters. Therefore, we expecting at least six month extra time to arrive at fruitful results.

10. **Objectives vis-à-vis achievements (clearly separate achievements reported in the previous meetings)**

Objectives	**Acheivements**
To develop a technique to assess the reliability of the spring flow as a sustainable source of drinking and domestic water by analyzing the flow characteristics	**<u>Upto March, 2012</u>** • Review of literature was in progress. • Collection and preprocessing of required spring flow data was under progress. • A fully automated objective-based method (adapted matching strip method) for master recession curve separation is tested for it accuracy and required modifications are carried out • Recession flow analysis of springs in the Chandrabhaga watershed using above mentioned method was in progress. • Major work on the mentioned objective was in progress
	<u>March, 2012 – Oct., 2012</u> • Preprocessing of the spring flow data for Danda Watershed was completed. • Recession flow analysis of springs in the Danda watershed using above mentioned method was in progress.

	Oct, 2012 – March., 2013 • Recession flow analysis of the springs in the Chandrabhaga and Danda watershed using fully automated objective-based method (adapted matching strip method) for master recession curve separation, especially estimation of average recession constants of the spring is completed.
To assess the potential for springs development as a water source	• Using these recession constants, an attempt will be made to incorporate topographic module to estimate morphological parameters of the spring watersheds using RS and GIS with hydrological module to arrive at aquifer hydraulic parameters and spring base flows. The research work on this objective will be completed within next 5-6 months.

11. Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken

Recommendations/suggestions	**Action taken**
36th WGM Dr. S. K. Bartarya suggested that it would be interesting if recession flow analysis may be made according to control/classification of springs such as Fracture joint or Fluvial related spring etc. (as given in Valdiya & Bartarya, 1991) or on types of aquifer. Further, he also suggested that tracers and isotopes may be incorporated as another tool.	• We are attempting to accomplish recession flow analysis according to control/classification of springs such as fracture joint or fluvial related spring etc. (as given in Valdiya & Bartarya, 1991) or on types of aquifer. • Regarding, suggestion on use of "tracers and isotopes as another tool", it is not possible to consider this suggestion in this study. However, this suggestion could be well taken in a separate study.
37th WGM No any specific suggestion/comment	NA

12. **Analysis and Results**

- Spring flow data for 20 springs in Chandrbhaga Watershed and 30 springs in Danda watershed has been obtained from previous studies. These time-series data sets have been checked for consistency and accuracy of the records.
- Time-series spring flow data is available on daily basis from July, 1999 to Feb., 2001 while twice daily or fortnightly data from 20 Feb, 2001 to 31 Dec., 2004 is available.
- A fully automated objective-based method (adapted matching strip method) was chosen for Master recession curve separation. This program extensively checked for the accuracy and necessary debugging is carried out. Using this program, preparation of master recession curves for all the springs in the Chandrabhaga and Danda Watersheds has been completed. The Recession equation obtained for some of the springs in both the watershed are shown in Tables 1 and 2. The details about assessment of spring and recession constant for these springs will be presented in the WG meeting.
- It is proposed that the parameters of recession equation obtained through this recession flow analysis will be used to identify the storage and aquifer characteristics during remaining period of the study.

Table 1. Recession flow equations for MRC separation for springs in Chandrabhaga Watershed.

Spring ID No.	Village	Three MRC's Separation				
		Separation range criteria, % of time that indicates flow or rate was equalled or exceeded	Optimal separation model Q%	MRC for segment	Regression equation	R^2
1	Dapoli	10% and 17%	14% and 56%	First	$Q = 0.1835e^{-0.0191t}$	0.76
		49% and 53 %		Second	$Q = 0.1546e^{-0.0142t}$	0.69
				Third	$Q = 0.2373e^{-0.0259t}$	0.91
				Average	$Q = 0.204e^{-0.02t}$	0.93
2	Badera	14% and 17%	16% and 53%	First	$Q = 0.2667e^{-0.0200t}$	0.75
		52% and 55 %		Second	$Q = 0.2282e^{-0.0129t}$	0.85
				Third	$Q = 0.3177e^{-0.02130t}$	0.90
				Average	$Q = 0.283e^{-0.02t}$	0.94
3	Kelan	1% and 5%	1% and 27%	First		
		22% and 27%		Second	$Q = 2.0297e^{-0.0163t}$	0.69

				Third	$Q = 5.9197e^{-0.032t}$	0.89
				Average	$Q = 4.022e^{-0.02t}$	0.92
			1% and 27%	First	$Q = 2.5531e^{-0.0309t}$	0.89
				Second	$Q = 1.4049e^{-0.0242t}$	0.59
				Third	$Q = 3.1714e^{-0.0531t}$	0.81
				Average	$Q = 4.022e^{-0.02t}$	0.88
4a	Bainsoli Malli-A	1% and 5%	4% and 45%	First	$Q = 0.9531e^{-0.0163t}$	0.83
		43% and 46%		Second	$Q = 0.6138e^{-0.0368t}$	0.69
				Third	$Q = 0.4492e^{-0.03370t}$	0.81
				Average	$Q = 0.600e^{-0.03t}$	0.92
4b	Bainsoli Malli-B	2% and 6%	4% and 76%	First		
		74% and 76%		Second	$Q = 0.9611e^{-0.0435t}$	0.75
				Third	$Q = 0.6576e^{-0.0329t}$	0.82
				Average	$Q = 0.802e^{-0.03t}$	0.90
5	Bainsoli Malli	2% and 6%	6% and 75%	First	$Q = 0.4433e^{-0.0558t}$	0.86
		73% and 76%		Second	$Q = 0.2246e^{-0.0289t}$	0.62
				Third	$Q = 0.1210e^{-0.0236t}$	0.84
				Average	$Q = 0.236e^{-0.03t}$	0.88
6	Bainsoli Malli	1% and 5%	4% and 75%	First	$Q = 0.2616e^{-0.0268t}$	0.90
		74% and 77%		Second	$Q = 0.2069e^{-0.0162t}$	0.76
				Third	$Q = 0.1977e^{-0.0165t}$	0.70
				Average	$Q = 0.210e^{-0.01t}$	0.87
7	Bainsoli Malli	1% and 5%	2% and 39%	First	$Q = 0.9907e^{-0.007t}$	0.96
		39% and 42%		Second	$Q = 1.3716e^{-0.032t}$	0.86
				Third	$Q = 0.6201e^{-0.0237t}$	0.89
				Average	$Q = 1.053e^{-0.02t}$	0.96
8	Bainsoli	1% and 5%	2% and 39%	First	$Q = 0.1845e^{-0.0105t}$	0.98
		40% and 43%		Second	$Q = 0.1469e^{-0.0223t}$	0.78
				Third	$Q = 0.1545e^{-0.0239t}$	0.87
				Average	$Q = 0.158e^{-0.02t}$	0.95
9	Bainsoli	1% and 5%	2% and 39%	First	$Q = 0.9408e^{-0.044t}$	0.84
		74% and 77%		Second	$Q = 0.5786e^{-0.0239t}$	0.69

				Third	$Q = 1.9608e^{-0.0432t}$	0.55
				Average	$Q = 0.681e^{-0.03t}$	0.81
10	Mingwali (near hospital)	1% and 5%	3% and 31%	First	$Q = 0.5588e^{-0.0380t}$	0.75
		25% and 35%		Second	$Q = 0.4568e^{-0.0225t}$	0.87
				Third	$Q = 0.9754e^{-0.0324t}$	0.84
				Average	$Q = 0.641e^{-0.02t}$	0.90
11	Dapoli	2% and 6%	3% and 32%	First	$Q = 0.5084e^{-0.05080t}$	0.94
		31% and 34%		Second	$Q = 0.3343e^{-0.037t}$	0.81
				Third	$Q = 0.7197e^{-0.0526t}$	0.78
				Average	$Q = 0.483e^{-0.04t}$	0.90
13	Bainsoli Talli	5% and 10%	7% and 45%	First	$Q = 1.8005e^{-0.03320t}$	0.73
		45% and 48%		Second	$Q = 1.3353e^{-0.0235t}$	0.84
				Third	$Q = 4.1004e^{-0.0478t}$	0.62
				Average	$Q = 2.436e^{-0.04t}$	0.80

Table 2. Recession flow equations for MRC separation for springs in Danda Watershed.

ID No.	Village	Three MRC's Separation				
		Separation range criteria, % of time that indicates flow or rate was equalled or exceeded	Optimal separation model Q%	MRC for segment	Regression equation	R^2
1	Danda	9% and 13%	9% and 45%	First	$Q = 1.7641e^{-0.03401t}$	0.94
		44% and 47 %		Second	$Q = 1.1022e^{-0.0286t}$	0.69
				Third	$Q = 1.5001e^{-0.0400t}$	0.73
				Average	$Q = 2.021e^{-0.04t}$	0.94
2	Guryali	8% and 13%	10% and 47%	First	$Q = 2.4848e^{-0.0275t}$	0.95
		47% and 52 %		Second	$Q = 0.8200e^{-0.0154t}$	0.51
				Third	$Q = 0.3688e^{-0.0090t}$	0.26
				Average	$Q = 2.0349e^{-0.03t}$	0.87
3	Rumdhar	4% and 11%	5% and	First		0.98

			45%		$Q = 0.9624e^{-0.0442t}$	
		44% and 50%		Second	$Q = 0.6858e^{-0.0477t}$	0.75
				Third	$Q = 0.3727e^{-0.0358t}$	0.86
				Average	$Q = 0.684e^{-0.048t}$	0.93
4	Tyari	34% and 36%	34% and 59%	First	$Q = 1.3073e^{-0.0192t}$	0.67
		55% and 61%		Second	$Q = 0.4791e^{-0.0112t}$	0.65
				Third	$Q = 2.5117e^{-0.03870t}$	0.83
				Average	$Q = 1.602e^{-0.03t}$	0.84
5	Burkot	34% and 36%	34% and 59%	First	$Q = 1.3073e^{-0.0192t}$	
		55% and 61%		Second	$Q = 0.4791e^{-0.0112t}$	
				Third	$Q = 2.5117e^{-0.03870t}$	
				Average	$Q = 1.602e^{-0.03t}$	
6	Rupado	1% and 7%	3% and 15%	First	$Q = 0.7925e^{-0.1130t}$	0.96
		14% and 17%		Second	$Q = 0.5472e^{-0.0658t}$	0.79
				Third	$Q = 0.3307e^{-0.0521t}$	0.96
				Average	$Q = 0.381e^{-0.05t}$	0.97
7	Mayali	5% and 12%	10% and 26%	First	$Q = 0.8905e^{-0.0448t}$	0.95
		24% and 30%		Second	$Q = 1.2154e^{-0.0956t}$	0.90
				Third	$Q = 0.7836e^{-0.0866t}$	0.69
				Average	$Q = 1.053e^{-0.02t}$	0.95
8	Mayali	1% and 5%	2% and 39%	First	$Q = 0.4602e^{-0.0104t}$	0.92
		40% and 43%		Second	$Q = 0.2841e^{-0.0341t}$	0.71
				Third	$Q = 0.3103e^{-0.0555t}$	0.71
				Average	$Q = 0.158e^{-0.02t}$	0.91
9	Mayali	10% and 20%	16% and 36%	First	$Q = 1.5650e^{-0.0503t}$	0.63
		34% and 40%		Second	$Q = 1.0618e^{-0.0332t}$	0.58
				Third	$Q = 1.167e^{-0.0431t}$	0.90
				Average	$Q = 1.538e^{-0.04t}$	0.97
10	Kanpolakhal	1% and 5%	3% and 31%	First	$Q = 0.3234e^{-0.0043t}$	0.98
		13% and 20%		Second	$Q = 0.2059e^{-0.0576t}$	0.51
				Third	$Q = 0.0719e^{-0.0233t}$	0.91
				Average	$Q = 0.096e^{-0.02t}$	0.89
11	Gajeli	1% and 5%	3% and	First		

			19%			
		16% and 21%		Second	$Q = 0.5470e^{-0.0205t}$	0.83
				Third	$Q = 0.3348e^{-0.0094t}$	0.80
				Average	$Q = 0.406e^{-0.01t}$	0.88
13	Rumdhar	1% and 5%	2% and 38%	First		
		34% and 40%		Second	$Q = 0.3557e^{-0.0521t}$	0.85
				Third	$Q = 0.1240e^{-0.0171t}$	0.47
				Average	$Q = 0.260e^{-0.03t}$	0.82
15	Rumdhar	1% and 5%	3% and 56%	First	$Q = 0.4588e^{-0.1197t}$	0.86
		54% and 58%		Second	$Q = 0.2304e^{-0.0376t}$	0.80
				Third	$Q = 0.0839e^{-0.0089t}$	0.81
				Average	$Q = 0.135e^{-0.01t}$	0.68
16	Rumdhar	1% and 5%	2% and 14%	First		
		12% and 20%		Second	$Q = 0.7094e^{-0.0140t}$	0.91
				Third	$Q = 0.4645e^{-0.0259t}$	0.86
				Average	$Q = 0.5712e^{-0.027t}$	0.92
17	Rumdhar	1% and 5%	2% and 46%	First		
		43% and 48%		Second	$Q = 0.2452e^{-0.0429t}$	0.86
				Third	$Q = 0.0841e^{-0.0158t}$	0.75
				Average	$Q = 0.146e^{-0.02t}$	0.79
18	Rumdhar	7% and 18%	16% and 32%	First	$Q = 0.3227e^{-0.0067t}$	0.95
		30% and 35%		Second	$Q = 0.3017e^{-0.0099t}$	0.54
				Third	$Q = 3.8821e^{-0.0397t}$	0.70
				Average	$Q = 0.7709e^{-0.02t}$	0.82

13. **Adopters of the results of the study and their feedback**

    N.A. at present

14. **List of deliverables** (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users interaction workshops)
    a) Papers
    b) Report

15. **Major items of equipment procured : NIL**

16. **Lab facilities used during the study: NIL**

17. Data procured and/or generated during the study

The following are the data requirement for the analysis of spring flow data using recession flow model

a) Daily precipitation and spring flow data
b) Information on catchment characteristics

These information's have been collected from previous study reports by NIH

18. **Study Benefits/Impact (2-column table showing achievements against measurable indicators as mentioned in the approved study document)**

Measurable indicators	Expected achievements
New technologies/processes	This study will provide improved methodology for analysis of spring flow data series in order to analyze the water resources availability in the study region.
Improvement in skill	It is expected

15. **Specific linkages with Institutions and/or end-users/beneficiaries**

NIL

16. **Shortcomings/difficulties, if any**

Nothing specific

17. **Future plan**

To be evolved at later stages of the study.

This study could not be initiated due to limitations on the part of the collaborator, i.e. IELO.

1. **Title of the study**:

   Pilot Basin Studies in Identified Sites at Six RCs/CFMSs (**Continuing Study**)

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

   Leader: Dr. V. C. Goyal, Sc F and Head, RMOD
   PI : One each from Divisions at the HQs and RCs/CFMSs

3. **Type of study**
   Internal (Jointly undertaken by NIH HQs and RCs/CFMSs)

3. **Date of start:** April 2012

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

5. **Study Area:** Total six pilot basins (one at each RCs and CFMSs) has been selected in consultation with the respective state government in which selected pilot basin is falling to address the existing water-related problems. The details about these pilot basins have been given in the Table 1.

6. **Study objectives**
   NIH proposed to undertake six Pilot IWRM Basin studies in different locations covering various agro-ecological regions in India (See Figure 1). With availability of its functional field units in these regions (RCs and CFMSs), NIH plans to establish advanced instrumentation systems for data collection and storage from these Pilot Basins. Analysis and modelling using state-of-art software models would be carried out on the data collected to derive meaningful results and findings for ultimate implementation and use by the stakeholders. With the help of specialists from other disciplines, the various stakeholders, including the local community, would be involved at different stages of planning, execution, evaluation, impact assessment, etc. It is hoped that the pilot studies would provide useful insight into the propagation of IWRM concept for sustainable development of water resources with community participation, which could be replicated in other areas.

   The proposed study aims to:

   i. establish advanced instrumentation systems for data collection and storage,
   ii. carry out analysis and modelling using state-of-art software models,
   iii. develop IWRM concept for sustainable development of water resources with community participation, which could be replicated in other areas.

Achievements:

a) Identification of pilot basin after confirmation from respective state government has been completed by all the RCs/ CFMS except CFMS, Guwahati. As per the program required to be achieved during last six month, one-day brainstorming session with the stakeholders (both Govt. & Non-Govt.) has been organized by Kakinada, Belgaum, Bhopal and Patna regional centre/CFMS of NIH. The details about these one-day brainstorming session organized at different place by RCs/CFMS along with

date and emerged water management issues are given in following Table. The session was structured as follows:

- IWRM and PBS concept
- Identification of gaps and issues
- Proposed work plan and deliverables
- Stakeholders' role and participation

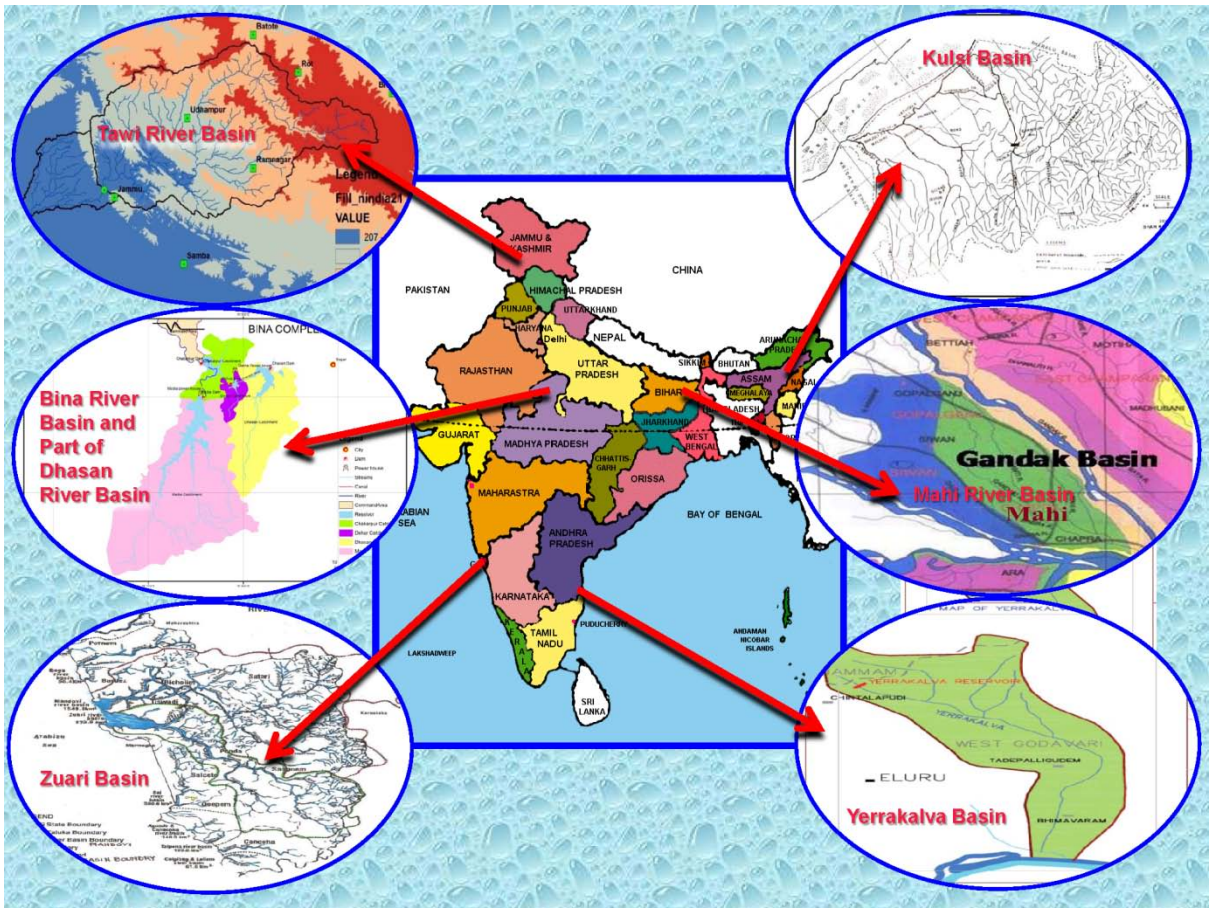


Figure 1. Pilot basins selected under IWRM-PBS program of NIH by its different RC/CFMS.

Pilot basin, RC/CFMS name, Venue of meeting and date of brainstorming session	**Emerged Water Management Issues**
Yerrakalva Basin, Andhra Pradesh **Deltaic Regional Centre, Kakinada**	• Water level depletion in the upland areas, water logging in delta areas and ground water salinity in the delta areas • Need of micro-level surveys on the impact of aquaculture on shallow aquifers • Demarcation of saline-fresh water interface has to be established in the coastal areas of the basin to avoid further degradation of groundwater quality

Meeting Hall, Data Centre, Eluru 31st Aug. 2012	• There is a necessity of a technique to find a way to safely dispose peak floods through Yerrakalva due to condition that the Yanamadurru drain has a discharge capacity of 8,000 cusecs and aqueducts built across the Yerrakalva river were designed for 20,000 cusecs at Nandamuru aqueduct and 1,50,000 cusecs at ISRMC crossing. • The major challenges to be addressed: groundwater issues of over exploitation in uplands; water logging in delta command area; water quality problem due to aquaculture; sea water intrusion into coastal aquifer etc. • Flood problem in the basin and back water effect due to old aqueduct at Chintaluru. • Need of lift irrigation schemes to mitigate flood problem • Poor quality of upstream waters of Yerrakalva basin • Scarcity of water during summer period
Bina river basin and part of Dhasan river basin of Betwa river in south Ganga plains **Ganga Plains South Regional Centre, Bhopal** WALMI Campus, Bhopal 29th Nov., 2012	• Water conservation for the entire post-monsoon requirements • Integrate social aspects in IWRM programme with thrust on socio-techno implementation activities • Regional hydrological formula for un-gauged basins in semi-arid regions required for water resources development in the region • Need of developing an institutional mechanism for better management of water resources in a basin • Sharing of natural resources data to be used in open software for DSS which can help in carrying out spatio-temporal changes and • Identify the gaps in resource data • Holistic approach is necessary for the water resources development of the region • Assessment of socio-economic impacts • Integrated development of habitats • Science communicators for spreading the awareness and conducting capacity building program in rural areas • Creation of Water Users Associations in command areas • Development of field channels and water courses • Proposal of AIBP programs for major and medium projects • Involvement of villagers and NGO's in the planning stage • Rules preparation for safe ground water exploitation • GW pollution aspects • Crop simulation modelling • Impact of land use change • Water quality studies • The methods and techniques available with CWC for Gauge & Discharge measurement, silt observation and water quality monitoring in river can be extended to NIH.

Zuari Basin, (Goa**)** **Hard Rock Regional Centre, Belgaum** State Hydrology Data Centre (Water Resources Department), Porvorim, Panaji 27th Nov. 2012	• Increasing salinity levels in the river and occurrence of flash floods • Water availability and water quality deterioration during lean periods • Water availability and water quality deterioration during lean periods • Change in land cover due to urbanization and mining activities within upstream reaches • Competing demands for water resources need to be analyzed more comprehensively to arrive at better methodologies and tools for understanding the hydrology of the region • Effect of mining on downstream river reaches • Siltation in reservoir due to mining • Rejuvenation of springs • Increasing levels of manganese in drinking water • Water use efficiency • Estimation of ET for the u/s reaches • Computation of runoff coefficient, infiltration, percolation etc. • Intensity-Duration-Frequency analyses • Environmental Flow Requirement • Salinity ingression into u/s river reaches • Control of evaporation from tanks/reservoirs • Identification of recharge zones • Effect of artificial recharge structures • Hydro-geological mapping • Crop water requirement • Salinity in estuarine region • Reclamation of salinity affected zones • Influence of land use changes on water resources • Effect of mining on acrecanut garden • Evaluation of pollution levels • Demarcation of zones of fresh water for fisheries • Water quality for agriculture • SRI system of agriculture • Introduction of micro-irrigation methods to reduce crop water requirement • Estimation of silt inflow • Watershed management/soil conservation • Utilisation of irrigation return flow • Effectiveness of bandharas in rivers • Management of abandoned mines • Influence of tides • Fresh water-saline water wedge • Agricultural pollution • Estuarine ecology • Identification of water quality hot spots

	• Demarcation of erosion potential zones
Mahi River Basin in Ghaghra-Gandak Composite Basin **Centre for Flood Management Studies (CFMS), Patna** 21st December, 2012	• Main problem is drainage congestion • Mahi river originated from the chaur needs to be made free from water logging by forced drainage • Flood inundation mapping due backwater effect of Ganga river studies during flood. • Water management studies for sustainable agriculture. • Assessment of WQ parameters like Arsenic, Fluoride, Nitrate etc. and pesticides for safe drinking and irrigation needs
Tawi River basin(Jammu) **Western Himalayan Regional Centre, Jammu**	Under Process
Kulsi basin (a part of the Brahmaputra sub-basin) **Centre for Flood Management Studies (CFMS), Guwahati**	Under Process

b) Preparation of detailed Status Report on the PBS as part of work program at each RC and CFMS during 2012-13 is under progress, covering the following points:
    - Statement of the problem
    - Review of studies carried out (by RC/CFMS (NIH) and other agencies)
    - Identification of gaps
    - Proposed study components to address the gaps
    - Data requirement for the study components and proposed instrumentation
    - Work plan and time line

Achievement: Draft of status report were submitted by the following RC/CFMS

a) Deltaic Regional Centre, Kakinada
b) Hard Rock Regional Centre, Belgaum
c) Centre for Flood Management Studies (CFMS), Patna (Require revision)

Other RC's/CFMS are preparing the status report.

Brainstorming Session: On the occasion of World Water Day (March 22, 2013) with the theme of "Water Cooperation", a 2-day Brainstorming session on "*Stakeholders' Cooperation and Participation in Developing IWRM Action Plan*" is being organized at New Delhi. In this event participations will be subject specialists drawn from different disciplines and NIH Scientist involved with the IWRM-PBS program. Dr. Mihir Shah, Memebr, Planning Commission (GoI) consented to inaugurate session on March 21, 2013 at 10:00 hrs.

Allotment of Work for next Six month: A core team of two scientists is desirable at different RCs which will be mainly responsible for the study. Other scientist at RC's and/or at different divisions at the HQ's may be involved for specific study components, depending on the requirement during different years. Based on the proceedings so far, the tentative core teams at different RC's are identified as follows and the work required to be undertaken in next six month is given in following Table:

RC/Sectt.@ Hqs	Core Team	
Sectt.@HQs	V C Goyal, Omkar Singh, R V Kale	Selection and procurement of required instruments for study
Belgaum	Chandra Mohan T, B Purendra	Selection of hydrological parameters and study components
Jammu	Pradeep Kumar, Manish Nema	-do-
Kakinada	Y R S Rao, S V Vijay Kumar	-do-
Bhopal	T R Nayak, T Thomas	-do-
Patna	B Chakravorti,N G Pandey	-do-
Guwahati	Sanjay Sharma, Gulshan Tirkey	-do-

Study No. 3 (New Study)

1. Title: Action Research for Water Conservation and Management in Selected Village (s) in Hardwar District (Uttarakhand)

2. Study Group: Omkar Singh, V.C. Goyal and C.K. Jain
3. Type of Study: Internal
4. Nature of Study: Dissemination of R&D activities
5. Date of start: April, 2013
6. Expected date of completion: March, 2015
7. Duration of the study: 2 year
8. Weather externally funded or not: Internal
9. Point wise objectives:

- Preparation of water conservation plan for the identified village (s)
- Assessment of water availability and water demand in selected village (s)
- Mass awareness activity for participatory water conservation & management

10. Statement of the Problem

Water conservation refers to reducing the usage of water and recycling of waste water for different purposes like domestic usage, industries, agriculture etc. Water conservation encompasses the policies, strategies and activities to manage fresh water as a sustainable resource to protect the water environment and to meet current and future human demand. In our country, most of the traditional sources of water in villages are on the verge of disappearing/shrinking due to encroachment and water quality deterioration leading to eutrophication. Therefore, a water conservation plan is necessary at village level to provide adequate and safe water for various purposes.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 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. Water harvesting offers one method of improving the livelihood of the people by reducing the uncertainty of human life in specially arid and semi-arid areas. Therefore, water conservation and its management of village ponds is essential for proper utilizing the water for beneficial use in the society.

11. Brief methodology:

It is proposed to assess water availability from the existing sources of water and demand for domestic, cattle and irrigation in the identified villages. Accordingly, a village pond near Roorkee will be selected and water balance components will be worked out using primary and secondary data. The water quality will be assessed and analyzed using standard methods for suggesting rejuvenation of the pond. The ground water level and quality will be monitored around the villages. The mass awareness activities will be carried out for participatory water conservation and management for benefit of society.

12. Mile Stones and Expected Outcome/Output:

- Technical Report
- Report on Mass awareness activity (s)