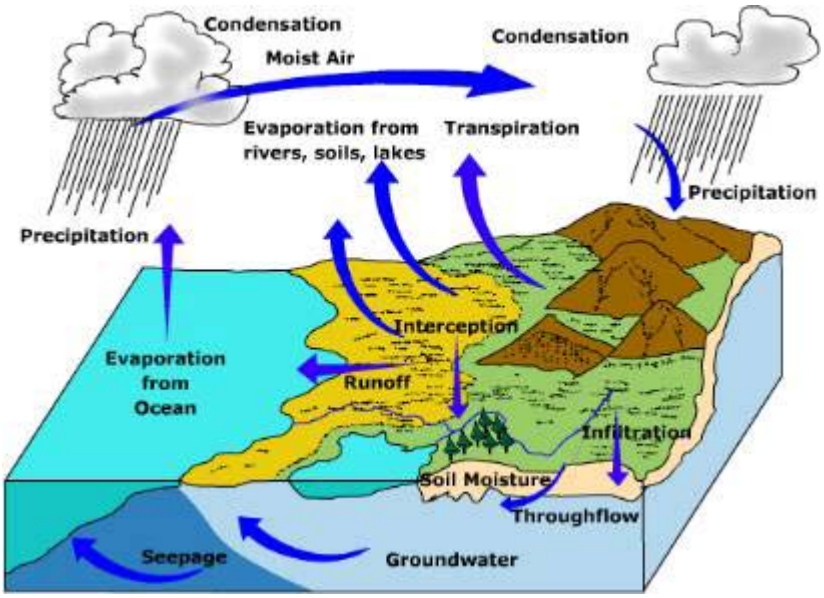
AGENDA AND AGENDA NOTES FOR THE 36th MEETING OF THE WORKING GROUP OF NIH

APRIL 3-4, 2012
AT 1100 HRS



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NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

AGENDA AND AGENDA NOTES FOR THE 36th MEETING OF THE WORKING GROUP OF NIH

AGENDA ITEMS

ITEM NO. 36.1 Opening Remarks by the Chairman

ITEM NO. 36.2 Confirmation of the minutes of 35th meeting of the Working Group

The 35th meeting of the Working Group was held during Oct 11-12, 2011. The minutes of the meeting were circulated to all the members and invitees vide letter No. NIH/RCMU/35th WG/11 dated Feb 22, 2012. No comments were received on the circulated minutes. A copy of the minutes of the 35th Working Group is given in **Annexure A.**

The Working Group may please confirm the minutes.

ITEM NO. 36.3: Action taken on the decisions/recommendations of the previous Working Group meeting

During the 35th Working Group meeting, the following recommendations/ suggestions had been made by the Working Group members. The actions taken shall be informed by the respective Divisions during the meeting.

SN	Item	Recommendations/suggestions	Action Taken
1	35.1	▪ Prof. K.C. Patra suggested providing a list of scientists under different Divisions along with the agenda item.	▪ Included in the present agenda.
2	EH Division Item#i	▪ The report will be submitted by 31 Oct 2011.	▪
3	EH Division Item#iii	▪ Final report is under preparation.	▪
4	EH Division Item#v	▪ Sri Ritesh Arya suggested collection of ground water samples from different depths. ▪ Dr Ravi Chopra suggested conveying finding/results to the concerned stakeholders by distributing pamphlets or by organizing mass awareness programme.	▪
5	GWH Division, Item#2	▪ Dr. R. Krishnan suggested collaborative studies between IITM, Pune and NIH for climate change studies.	▪
6	GWH Division, Item#3	▪ Impact of spreading channel on groundwater system will be considered in the study.	▪
7	GWH Division, Item#4	▪ PI was advised to go through MAR scheme document of Maharashtra. ▪ Dr. Muralikrishnan Rao informed availability of data useful for the study.	▪
8	GWH Division, Item#5	▪ Draft copy of the document would be ready by December 2011. A workshop would be organized in the end of January, 2012	▪
9	HI Division, Study#NIH/HID/ DST/07-12	▪ Er. R.D. Singh suggested to develop isotope based empirical relations for forecasting of monsoon.	▪

		▪ Dr. Rao and Dr. Kakade emphasized on establishing few more stations for understanding the regional dynamics of vapour. They also suggested incorporation of other met conditions necessary for precipitation in interpretation of the data towards monsoon prediction. ▪ Dr. Arya advised to develop a few stations for isotope analysis in high altitude cold deserts or alpine areas. ▪ Dr. S.K. Singh suggested to identify the time required for vapours to travel between two NIH-IWIN stations and to use it in predicting the onset and withdrawal of monsoon. ▪ Dr. B.P. Singh suggested to estimate onset and withdrawal dates of monsoon using δ^{18} O and δ D independently and to inter-compare these dates to confirm the validity of technique.	
10	HI Division, Study#NIH/HID/ HP-II/09-12	▪ Dr. Grewal suggested contribution of canals to groundwater recharge from Balachaur to Nawanshahr should be reconfirmed in the present study.	▪
11	SWH Division, Item#1	▪ Chairman, WG, suggested presentation of complete work in the next working group meeting.	▪
12	SWH Division, Item#5	▪ Chairman, WG, suggested that one of the objectives must reflect the Climatic variability analysis and its impact on watershed and be amended.	▪
13	SWH Division, Item#7	▪ Prof. Perumal suggested trial of available runoff-volume models in HEC-HMS.	▪
14	WRS Division, Item#1	▪ Results of NIH model will be compared with other models bringing out the advantages/ limitations of distributed models in comparison to the semi-distributed models.	▪
15	WRS Division, Item#2	▪ Sh. Kishor Kumar suggested -to include/ refer to the GIGB guidelines given by the Govt for the security of the websites; and -to include/provide in the system the information about RRR and a two-way link to the information and updates from the Ministry's and CWC's sites maintaining such details. ▪ Dr. Perumal suggested considering the information on lakes prepared by Sunita Narayan.	▪
16	WRS Division, Item#8	▪ The work at Largi in Beas basin for soil erosion will be consulted for the present study.	▪

ITEM NO. 36.4: Achievements during the 11th Plan period.

The thrust areas and studies carried out by different divisions during the 11th Plan are listed in the following table:

Coverage of Thrust Areas & Studies by Divisions during 11th Plan Period

Division → Theme and Studies ↓	EH	GWH	HI	SWH	WRS	RCMU
I. Hydrology of Extremes						
1. Flood routing				√		
2. Real time flood forecasting				√		
3. Dam break flood wave simulation				√		
4. Flood plain zoning				√		
5. Flash floods studies				×		
6. Flood estimation				√		
7. Integrated drought vulnerability assessment				√		
8. Drought characterization in different climatic regions				√		
9. Regional drought studies				√		
II. Impact of Climate (landuse) Change on Water Resources						
1. Impact of urbanization on hydrologic regime	√					
2. Land use changes vis-à-vis hydrological components					√	
3. Sedimentation and soil erosion in lake catchments			√			
4. Forest hydrology and socio-economics				√		
III. Groundwater Modeling and Management						
1. Resource estimate and water availability studies						
2. Aquifer dynamics and artificial recharge and resource management		√				
3. Inverse modeling for source identification		√				
4. Surface water groundwater interaction		√		√		
5. Management of groundwater in hard rock formations.		√				
6. Management of coastal aquifers		√				
7. Fresh water saline water interactions		√				
8. Groundwater contamination and remediation	√					
9. Aquifer remediation, wellhead protection and management	√					
10. Impact of climate change on groundwater		√				
11. Groundwater-environment-energy interaction						
12. Impact of inter-basin transfer of water on groundwater regime						
13. Policy evaluation modeling for groundwater management and its						

regulation						
IV. Sustainable Water Systems Management 1. Risk based management of water systems 2. Cumulative impact of dams and diversions 3. Adaptation of hydro-systems to climate change 4. Assessment of water demand and availability using spatially distributed modeling 5. Inter-basin water transfer 6. Conjunctive use of surface water and aquifers 7. Hydro-informatics for water systems management 8. Water, energy and food security nexus 9. Spatial estimate of AET using RS data 10. Data driven models for analysis of water systems				√ √ √ √ √ √		
V. Surface Water Modeling and Regional Hydrology 1. Prediction of extreme hydrologic events in ungauged catchments 2. Design flood estimation for gauged as well as ungauged catchments 3. Water availability 4. Hydrological modeling 5. Isotopic characterization of water resources on regional scale			√	√ √ √ √		
VI. Environmental Hydrology 1. Water quality and human health 2. Natural and organic contaminants 3. Non-point source pollution 4. Assessment of environmental flows 5. River bank filtration for water supply 6. Sediment dynamics 7. Integrated hydrological studies of lakes 8. Low cost treatment/remediation technologies	√ √ √ √ √ √	 √	 √			

ITEM NO. 36.5: Thrust areas/activities proposed during the 12th Plan.

The thrust areas and studies proposed by different divisions during the 12th Plan are listed in the following table:

Involvement of Divisions in Thrust Areas & Studies during 12th Plan Period

Division → Theme and Studies ↓	EH	GWH	HI	SWH	WRS	RCMU
I. Hydrology of Extremes						
1. Flood management				√		
2. Urban flooding				√		
3. Drought mitigation and management				√		
4. Glacier lakes outburst flood				√		
5. Early warning systems				√		
II. Regional Hydrology		√		√		
III. Environmental Hydrology						
1. Pollution from point and non-point sources	√					
2. Water quality and health	√					
3. Environmental flow in rivers	√					
4. River bank filtration studies		√				
5. Water treatment/ remediation technologies	√					
IV. Integrated Water Resources Management (IWRM)						
1. Hydrology for sustainability of water sources					√	
2. Integrated operation of reservoirs					√	
3. Groundwater management		√				
4. Conjunctive use of surface and Ground Water		√			√	
5. Pilot basin studies	√	√	√	√	√	√
6. DSS (Planning) activities		√		√	√	
7. Hydrological studies in Brahmputra basin	√			√	√	
V. Hydrology for Watershed Management						
1. Forest hydrology				√		
2. Hydrology for springs management		√	√			√
3. Hydrology of lakes and other water bodies	√		√			
4. Water management in mined areas	√		√			
5. Water management in salinity-affected areas	√	√				
6. Water management in coastal and hard rock aquifers		√				
7. Impact assessment studies	√					
VI. R&D Under National Water Mission						
1. Development / implementation of modern technology for measurement of various data						√

2. Research and studies on all aspects related to impact of climate change on hydrologic cycle and water resources, including quality aspects	√	√	√	√	√	√
3. Projection of the impact of climate change on water resources				√	√	
4. Dynamics of deeper aquifers		√				
5. Centre for Climate Change Studies				√		
6. Centre for Snow & Glacier Studies				√		
VII. Technology Transfer and Outreach Activities						
1. Training workshops	√	√	√	√	√	√
2. Seminars/symposia	√	√	√	√	√	√
3. User interaction workshops						√
4. Science-policy interface						√
5. IPR issues in hydrology and water resources					√	√
6. PPP linkages					√	√

ITEM NO. 36.6: Presentation and discussion on the status and progress of the work programme for the year 2011-2012.

The approved Work Programme of the six Divisions of the Institute for the year 2011-12 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:

Division	**Studies**		**Total**
	Internally funded	Sponsored (including HP-II)	
Environmental Hydrology	04	02	**06**
Ground Water Hydrology	04	02	**06**
Hydrologic Investigation	05	06	**11**
Surface Water Hydrology	09		**09**
Water Resources System	06	03	**09**
RCMU	01		**01**
Total	**29**	**13**	**42**

During the present meeting, Division-wise progress and status of the work programme for the year 2011-12 shall be presented in detail. The Working Group may please consider the progress and status of the Work Programme for the year 2011-2012.

ITEM NO. 36.7: Presentation and finalization of the work programme for the year 2012-2013.

The proposed 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 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 2012-13 shall be presented.

Division	**New**		**Ongoing**		**Total**	
	Internally funded	Sponsored (including HP-II)	Internally funded	Sponsored (including HP-II)		Consultancy Projects
Environmental Hydrology	01		02		**03**	
Ground Water Hydrology	01	01	02	03	**07**	**01**
Hydrologic Investigation	01		03	05	**09**	**02**
Surface Water Hydrology	02		06		**08**	**06**
Water Resources System	04		02	01	**07**	**02**
RCMU	02		01		**03**	
Total	**11**	**01**	**16**	**09**	**37**	**11**

The Working Group may please consider the proposed Work Programme for the year 2012-2013.

ITEM NO. 36.8: Any Other Item with Permission of the Chair.

ANNEXURE – A

MINUTES OF THE 35TH MEETING OF WORKING GROUP

MINUTES OF THE
35TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING OCTOBER 11-12, 2011

The 35th meeting of the Working Group of NIH was held at NIH, Roorkee, during October 11-12, 2011 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in **Annexure-I**.

ITEM NO. 35.1: OPENING REMARKS BY THE CHAIRMAN

The Chairman, WG welcomed the Working Group members and the Scientists of the Institute. He apprised the members on the organizational structure of NIH, and on the role of Working Group in the technical programme of the Institute. The Chairman mentioned that based on the recommendations of the Technical Advisory Committee (TAC), the Working Group composition has been revised, and this is the first meeting of the reconstituted Working Group.

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

S N	Member	Suggestion(s)
1	Sh. R C Jain	▪ Emphasized on the need of studies for sustainable aquifer management, in terms of conservation and augmentation of ground water. ▪ Assessment of deeper acquifers. ▪ Issues related to aquifer pollution and remediation needs to be addressed on priority basis. ▪ Involvement of local people as well as civil organization is needed for achievement of sustainable ground water management and accordingly strategies needs to be chalked out.
2	Sh. R M Bhardwaj	▪ Demand driven economic and water consumption pattern are going to change drastically which should be addressed properly with emphasis on water quality aspects. ▪ We need a vision document to indicate how to manage water resources as per the need of population in the year 2050.
3	Dr. Kishore Kumar	▪ Creation of reliable database using modern technologies such as ICT. ▪ Development of government to community interface.
4	Dr. R. Krishnan	▪ IITM is using high resolution climatic models and the data of these models can be used in river basin simulation modeling to assess the impact on runoff under different climate scenarios. He expressed his desire to collaborate with NIH in these studies. ▪ He informed that IITM has started training in climatic sciences for B. Tech, M. Tech and PhD students. During these trainings, interested scientists from

		NIH may also participate.
5	Dr G P Juyal	▪ Mentioned the need of studying hydrology of landuse changes ▪ Work for rejuvenation of water sources.
6	Sh. A K L Asthana	▪ Studies on glacier water management and hot water streams in Himalaya need to be undertaken.
7	Dr. R K Goyal	▪ Studies on arid-zone hydrology; flash flood management; and improvement of water quality need to be undertaken.
8	Dr. M P Singh	▪ Need to investigate impact of land use and land cover changes on various hydrological processes.
9	Dr. V V Rao	▪ Emphasized on the need of studies related to urban hydrology. ▪ Studies on climate change and required adaptation strategies. ▪ Micro-level groundwater studies. ▪ Collaborative studies with IITs and other academic institutes needed. ▪ Studies should be undertaken on water productivity and water fingerprinting.
10	Er. Ravindra Kumar	▪ Water resources development and management projects should address various environmental concerns. ▪ Assessment of irrigation potential for Himalayan regions and reuse of river water should be undertaken. ▪ Storm water management should get priority in National Water Mission. ▪ Need to give more emphasis to Ganga basin management plan.
11	Sh. Niladri Naha	▪ Studies on drought management and coastal water management need to be undertaken.
12	Sh. B.M. Murali Krishna Rao	▪ He explained about the problem of ground water in hard rock regions such as in Andhra Pradesh. ▪ He emphasized on the need of studies on integrated approach in alluvial and hard rock region basins, ground water exploitation, establishment of rainfall and ground water recharge relationships, Water balance, soil and water salinity, pollutant transport etc. ▪ Need of guidelines on pumping of ground water quantity to stop sea water intrusion into coastal aquifer. ▪ Need to investigate aquifer parameters for deeper aquifers, and studies for establishment of relationships on depth versus storage, and depth versus quality. ▪ He informed that his department has collected lot of ground water data and they are interested in collaborative studies with NIH.
13	Prof. J S Rawat	▪ Studies on water availability in non-glacial fed rivers in Himalayan region. ▪ Hydrological studies in landslide prone areas.

		▪ Groundwater augmentation and recharge in headwater regions. ▪ Hydrological studies in rainfed areas.
14	Prof. K.C. Patra	▪ Advocated the opening of the climate change centre to study impacts of climate change on hydrological processes. Dr V C Goyal infomred that a centre already exists at NIH, which will be further strengthened during the 12th Plan. ▪ He suggested providing a list of scientists under different Divisions along with the agenda item.
15	Dr. M. Perumal	▪ NIH should concentrate more on development of physically based hydrological models. ▪ Institute should significantly contribute for the development of hydrological science, and publications in peer-reviewed journals. ▪ There is a need for organizing long term training certificate courses at par with IIRS, ISRO etc. for dissemination of knowledge to field organizations.
16	Dr S S Grewal	▪ He argued that there is need to identify end user of the studies. ▪ Need of making policy changes based on the results achieved through the research studies. There should be proper link between line departments and R&D institutes to address policy issues properly. ▪ Need of studies on changing hydrology in light of interventions due to hydro-electric power projects, widening of roads etc., in Himalaya region. ▪ Studies on impact of watershed development on hydrological changes, and the environmental impact assessment in Himalaya region. ▪ Integrated water management approach should be addressed in national programs like MGNREGA with the help of rural development departments. ▪ Need for development of technology/mechanism for pond water use in irrigation management.
17	Dr Ritesh Arya	▪ Development of model for ground water assessment in Himalayan region. ▪ Development of environmental hydrology and protection of water bodies.
18	Dr A J James	▪ There should be role of NIH in policy making as well as in implementation of findings by the Institute in the field. ▪ Need of carrying out studies on dam operation in view of the climate change. ▪ Need for addressing the problem of declining ground water level throughout the country due to over exploitation of ground water.
19	Dr Ravi Chopra	▪ In view of fastest growing urbanization and increased water demands, studies should be undertaken on development and management of urban water systems. ▪ Studies on river conservation, especially Himalayan rivers.

		▪ Studies for flood management and on use of early warning systems. ▪ Hydrology of traditional water harvesting systems.
20	Dr.(Mrs) K Vijaya Lakshmi	▪ Studies should be user friendly and end users should be part of the study. ▪ Need to enhance outreach and dissemination. ▪ Need to undertake more hydrological studies in semi-arid region *viz*., water budgeting, regional water availability, and economics of water use. ▪ Upstream and downstream water sharing issues, ecosystem and sustainability of the hydrological model should be incorporated in the research studies.
21	Dr A P Singh	▪ Develop decision making tools for user community. ▪ Study vulnerability of groundwater systems. ▪ Studies on non-point source pollution. ▪ Studies on water-energy relationships.
21	Shri Bharat K. Kakade	▪ Develop capabilities through training of manpower for watershed management programmes. ▪ Studies on productive use of water. ▪ Link research findings with livelihood programmes. ▪ Need of hydrological studies in coastal areas and desert prone areas e.g. in Maharashtra and Karnataka. ▪ Need to develop outreach programmes with project implementing agencies. ▪ Utilize efficient hydro-informatics techniques.

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. 35.2: CONFIRMATION OF THE MINUTES OF 34TH MEETING OF THE WORKING GROUP

The 34th meeting of the Working Group was held during April 7-8, 2011. The minutes of the meeting were circulated to all the members and invitees vide letter No. NIH/RCMU/34th WG/11 dated May10, 2011. As no comments were received on the circulated minutes, the minutes were confirmed.

ITEM NO. 35.3: 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 34th working group meeting.

ITEM NO. 35.4: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2011-2012.

The Member-Secretary made a brief presentation outlining progress made under different studies for the work programme of 2011-12. Division wise progress on each study/project presented during the meeting is given in the next section.

ENVIRONMENTAL HYDROLOGY DIVISION

i) Assessment of Ground Water Quality in Class I Cities in India - Phase II (CPCB sponsored project)

Dr M K Sharma presented the progress of the project and he informed that out of twenty five class I cities, twenty four cities had been already covered during the year 2009-10 and 2010-11. He further informed that twenty fifth Shrinagar was replaced by Gautambudhnagar by CPCB on the request of NIH due to security reasons and an extension of the project upto October 2011 has been given by CPCB. The pre- and post-monsoon sampling of Gautambudhnagar has been completed. About thirty samples were collected from open wells, ring wells, bore wells and handpumps from each of these cities covering residential, industrial, petroleum storage, landfill sites. Collected samples were analysed for various water quality constituents viz; major cations and anions, metal ions, bacteriological parameters and metals. Pesticides residue and PAH analysis were under progress. Dr Sharma presented the results of the study. In a query raised by Dr R C Jain about the presence of nickel in ground water samples of north-eastern cities, Dr Sharma informed that the probable source of presence of nickel in ground water may be wash off from small industrial units of Ni-Cd batteries existing in cities. Dr Bhishm Kumar suggested to present results pin pointing the specific locations in each city. Dr Sharma replied spatial distribution maps have been prepared showing the water quality degraded zones for each city. The report is under writing and will be submitted by 31 October 2011.

ii) Impact of sewage effluent on drinking water sources of Shimla city and suggesting ameliorative measures

Dr. V.K. Choubey, Scientist F & Head/PI given an overview of this study. Thereafter, the detailed progress was presented by Mr. Omkar Singh, Scientist E2 and Dr. Rajesh Singh, Scientist B, respectively. He informed that field investigations have been re-scheduled as per suggestions given by Dr. R.C. Trivedi (TAMC/PCS) and monthly monitoring of various water quality parameters is in progress. The PI also informed that a 3 days training course on “Water quality & its Management” was organized in collaboration with I&PHE Dept Shimla for their officials at HIPA, Shimla. The final report would be submitted as per given time frame for this PDS under HP-II.

iii) Spatial Variability of Ground Water Quality in Kandi, Sirowal and Shiwalik Belts of Jammu Region, J&K (India)

After brief introduction, the study was presented by Shri Omkar Singh, Scientist E1 & PI. He informed that the spatially variability analysis of the groundwater quality data has been completed. The results have been compared with those of the old data sets for various physico-chemical parameters. Accordingly, ground water quality monitoring network in the study area have been proposed. Spatial variability maps of various ground water quality parameters have also been prepared. Shri R K Jain enquired about the field applications of the

findings related to spatial variability. PI informed that a report would be sent to the concerned local organizations for possible strengthening of their monitoring programs. The final report is under preparation.

iv) Development of Low Cost Media for Fluoride Removal from Drinking Water of Fluoride Affected Areas

Dr. Rajesh Singh, Scientist 'B' presented the brief introduction about the objective and progress made in this study. He informed that major review work has been completed so far and a suitable media would be developed by collecting fresh bagasse fly ash from nearby sugar industries. No comments were received.

v) Assessment of Groundwater Quality in Hindon River Basin

Dr M K Sharma presented the scope of the study and its brief description. Dr Sharma elaborated the work plan to be carried out for the study. Sri Ritesh Arya suggested to collect ground water samples from different depths in order to have proper picture of the study area. Dr Ravi Chopra suggested to convey the finding/results of the study to the concerned stakeholders by distributing pamphlets or by organizing mass awareness programme.

GROUND WATER HYDROLOGY DIVISION

Dr. N. C. Ghosh, Scientist-F & Head of the division presented an overview of the technical activities carried out by the division & progress made on different studies during last six months. He informed that there are total of 5 research studies approved for the division under the current year, out of which 4 are internally funded, and remaining one is purpose driven study under HP-II. In addition to the 5 research studies, Dr. Ghosh informed that as follow-up of the MOU signed between NIH & HTWD, Germany, NIH has participated in the multi-stakeholders collaborative R & D project sponsored by the European Commission under 7th Framework programme entitled *"Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India"*. The project has seven Work Packages, out of which NIH is participating in 4 Work Packages with budgetary allocation of 2, 42,044 Euros for the duration of 36 months starting from October, 2011.

He further gave an account of initiatives taken by the division during last six months, and results thereof. Few important initiatives taken up by the division are as follows:

- A Memorandum of Understanding (MOU) with the University of Applied Sciences Dresden (HTWD), Germany for establishment and cooperation of an *"Indo-German Competence Centre for River Bank Filtration (IGCCRBF)"* at NIH has been signed on 30th May, 2011.
- As follow-up of the Workshop organized by the Ministry of Earth Sciences under the Indo-US bilateral programme, An Indo-US collaborative project entitled **"***Modeling Groundwater and Surface Water Availability in an Agricultural Area"*.**"** jointly with USGS, ICAR & ISRO has been developed & submitted to the Ministry of Earth Sciences, Govt. of India for evaluation and further necessary action.
- As follow-up of the MOU with the University of Applied Sciences Dresden, Germany, An Indo-German CLIENT pre-project proposal entitled *"Safe and sustainable drinking water production by coupling natural and innovative techniques in India*" jointly with Germany, NEERI, UJS, IITRoorkee, IIT Madras, Kalyani University has been

prepared & submitted to DST, Govt. of India for evaluation and further necessary action.

- An Indo-Italy collaborative project proposal entitled *"Arsenic affected groundwater and agricultural soils: Integrated assessment of impacts, remediation measures and exploring solutions"* jointly with Italy, and IIT Roorkee has been prepared & submitted to DST for evaluation and further necessary action.

In addition to the above R & D studies, the division is working on one Consultancy Project *"Feasibility study of surface water and groundwater availability including identification of potential groundwater recharge sites in the CIFMR campus, Dhanbad"* of 6 months duration with Rs. 15.07 lakhs supported by the Engineering Projects (India) Ltd. , A Govt. of India Enterprise is in progress since August, 2011. Another consultancy Project entitled "Drainage Area mapping and hydrological studies in and around Gurha (W) Lignite Block in Kolayat tehsil of Bikaner District, Rajasthan" of 9 months duration with Rs. 12.5 lakhs from Rajasthan State Mines & Minerals Ltd, - A Govt. of Rajasthan Enterprise is underway.

Dr. Ghosh informed that Scientists of the Division have submitted/published a number of research papers in various journals/conferences/symposia during the period and also delivered lectures in various training courses.

Thereafter, Dr. Ghosh requested the concerned PIs to present the detailed progress of each study. The Study-wise suggestions and discussions emerged are given below.

1. QUANTIFICATION OF IMPACT OF RAINWATER HARVESTING ON GROUNDWATER AVAILABILITY IN ARAVALLI HILLS – PART II: MATHEMATICAL MODELING

Mr. C. P. Kumar explained about the data monitoring and field investigations carried out in Savana macro-watershed including the morphometric analysis, monitoring of soil moisture variation and trial runs using VS2DT model. The role of morphometric analysis in the present study was enquired. It was informed that morphometric analysis is helpful for identifying suitable sites for rainwater harvesting structures. Dr. B. P. Singh suggested to use nuclear techniques for estimating recharge. Mr. Kumar informed that tracer technique using stable isotopes has already been undertaken for the study area. The members opined that such studies need to be undertaken for other areas also.

2. IMPACT OF CLIMATE CHANGE ON DYNAMIC GROUNDWATER RECHARGE IN A DROUGHT PRONE AREA

Mr. C. P. Kumar presented the projected rainfall and temperature for the Sonar basin for years 2039, 2069 and 2099 based-upon IPCC SRES scenarios (A1FI and B1) and estimation of groundwater recharge at 12 locations using Visual HELP model for future climate scenarios. On a query, it was informed that future changes in land-use pattern have not been considered for the present study. It was suggested that in view of uncertainty in GCM predictions and IPCC projections for SRES scenarios, the estimation of recharge and corresponding estimation of groundwater fluctuation should also be worked-out for various other scenarios different from SRES scanarios. Dr. R. Krishnan expressed the desire to take-up collaborative studies between IITM, Pune and NIH for climate change studies.

3. COASTAL GROUNDWATER DYNAMICS AND MANAGEMENT IN THE SAURASHTRA REGION, GUJARAT.

Mr. C. P. Kumar presented the objectives of the study, salient features of the study area, details of data collection program undertaken for the Minsar Basin, geology of Minsar Basin,

variations in water table and groundwater salinity along the coast, drilling of piezometers by GWRDC, procurement and use of equipment (salinity data loggers, TLC meter, resistivity meter) and field studies (infiltration and hydraulic conductivity tests) undertaken. On a query, Mr. Kumar informed that impact of spreading channel on groundwater system will be considered in the modeling study. It was enquired if the groundwater salinity at very large depths in inland areas is being studied. Mr. Kumar informed that objective of the present study is mainly inclined towards assessment of seawater intrusion in coastal tracts. On a query from Dr. Bhishm Kumar, Mr. Kumar informed that at few localized points, the groundwater table has been found to be below sea level due to heavy groundwater withdrawal near the coast, but in general groundwater outflow to sea occurs.

4. MANAGEMENT OF AQUIFER RECHARGE (MAR) AND AQUIFER STORAGE RECOVERY (ASR)

Mr. Sumant Kumar (PI) presented the objectives, achievements and the future plan for the proposed study. It was informed that MAR schemes have been developed in Maharashtra and PI was advised to go through that particular document. Dr. Muralikrishnan Rao told that they are having some data which can be useful for the study.

5. GROUND WATER FLUORIDE CONTAMINATION IN DIFFERENT PARTS OF INDIA

As decided in the 34th Working Group, the study was reduced to prepare only a Status Report on the problem of ground water fluoride contamination in India. The members, however, suggested that the process should not be stopped as each report would bring out new concepts to fight against the growing problem creating hazard in various pockets of the country. Such efforts would definitely save time for the researchers willing to contribute to this noble cause.

Mr. Dwivedi briefed the outlines and the possible outcomes of the study and sought view of the members to improvise content of the document. Mr Dwivedi informed that the draft copy of the document would be ready by December 2011. He proposed to organize a workshop on the topic sometimes in the end of month of January, 2012 to enrich the content and recommendations before it the document is finalized. The members agreed with the proposal.

6. NEW PROJECT: "SAPH PANI - ENHANCEMENT OF NATURAL WATER SYSTEMS AND TREATMENT METHODS FOR SAFE AND SUSTAINABLE WATER SUPPLY IN INDIA"

Dr. N. C. Ghosh informed that as follow up action of the MOU signed between NIH and Division of Water Sciences, University of Applied Sciences Dresden (HTWD), Germany for establishment and operation of an *"Indo-German Competence Centre for River Bank Filtration (IGCCRBF), NIH and HTWD* joining in a consortium of 20 organizations (10 Indian and 10 Foreign) from 8 different countries have developed and submitted a collaborative R & D Project entitled **"**Saph Pani - Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India" in respect of the call of the European Research Commission 7th Framework Program, and qualified to receive grants of about 3.5 million Euros for the project of 36 months duration. The project has been launched from October, 2011.

The Project has seven Work Packages, (i) Bank filtration in urban areas under varying pollutants load and flood situation, (ii) Managed aquifer recharge and soil aquifer treatment,

(iii) Constructed wetlands and other natural treatment systems for wastewater treatment and reuse, (iv) Post treatment of water from natural treatment for different applications, (v) Modeling and system design, (vi) Integrated sustainability assessment, and (vii) Training & dissemination. Out of these 7 Work Packages, NIH has participation in WPs(i, ii, v and vii). For WP (vii), NIH is the leader, while for other packages NIH is one of the working partners for specific components.

Dr. Ghosh presented the objectives of different WPs in which NIH is involved, and elaborated the tasks to be carried out by NIH. It was also informed that during 3-4 November, 2011, the inception meeting of the project to be organized by NIH has been scheduled at New Delhi, in which all partners would be attending to get familiar to each other and the tasks to be carried out in coming one year.

HYDROLOGICAL INVESTIGATIONS DIVISION

Dr. Bhishm Kumar, Sc. F and Head of the Division presented in brief the various studies being carried out by the Division. He also informed about the number of research papers published/accepted for publication/communicated by the scientists of the Division. Analytical work carried out at the Nuclear Hydrology Laboratory was also presented. He also informed the members about the other activities of the institute in which the scientists of the HI Division are involved.

The progress of studies was presented by the respective P.I. of the study as given under:

Study No. : NIH/HID/NIH/09-12: **SURFACE WATER AND GROUNDWATER INTERACTION AT SELECTED LOCATIONS ALONG RIVER YAMUNA IN NCT, DELHI**

Dr. Sudhir Kumar presented the progress of the study and explained the key findings. Dr. Sudhir Kumar informed that isotopic work for the project has been completed and the 3D mathematical model has been setup. The model is being calibrated. The parameters obtained from the isotopic analysis and the field measurements shall be incorporated in the model. He further informed that isotopic studies have indicated that the vertical recharge from flooding dominates during monsoons. The lateral recharge is slow and the water due to lateral movement of water will take longer time (2-3 years) in reaching the pumping wells, whereas, the water recharged due to flooding reaches within very short time.

Study No. :NIH/HID/HP-II/09-12: **GROUNDWATER MANAGEMENT IN OVER-EXPLOITED BLOCKS OF CHITRADURGA AND TUMKUR DISTRICTS OF KARNATAKA**

Dr. Sudhir Kumar presented the work done under the project during the last six months. He informed that during this period, pump tests have been conducted in tubewell and dugwells at 4 locations in watershed in Tumkur District. Resistivity surveys were carried out at 16 locations (8 each in Tumkur and Chitradurga Districts). Automatic water level recorders and automatic rain gauges were installed

in both the watersheds. It was also informed that in most of the years, the groundwater wells show recuperation after the monsoon and there is no long term decline in water table except during the low rainfall years. He further informed that no outflow has been observed at the outlet of the watersheds during last 8-10 years and all the precipitation water gets stored in the tanks.

Study No. : NIH/HID/DST/07-12: **NATIONAL PROGRAMME ON ISOTOPE FINGERPRINTING OF WATERS OF INDIA (IWIN)**

Dr. M. S. Rao presented the progress of the study. He started with the action taken on the comments of the 34th Working Group meeting. The isotopic correlation among the IWIN sampling stations Roorkee, Sagar, Jammu and Kakinada were shown with special emphasis on the correlation between Roorkee and Sagar. The progress for the period April, 2011 to September, 2011 was initiated with the establishment of three more sampling stations at Tezpur University, Assam, IIT-Kanpur and Manali for collection of Ground Level Vapour (GLV). A total of 1154 samples were collected from April, 2011 to September, 2011 from Roorkee, Sagar, Kakinada, Jammu, Tezpur, Kakinada, Kanpur and Manali and out of which 650 number of samples have been analysed. These include GLV, rainwater, groundwater and river water. Using GLV – isotopic time series data (2007-11), he has explained the significance of the isotopic composition of GLV in identifying arrival and departure of monsoon and shown its significance in monitoring the climate change which is also reflected in the change in winter temperature and reduction in sustaining the maximum temperature. To extend the objective of study from ground based to vertical profile (500-1000m), balloon based new experiments was also highlighted and work achieved towards this was explained. The invited experts highly appreciated the objectives and achievements of the study due to its national and international importance as it is addressing the onset and withdrawal of monsoon and its regional dynamics.

The comments given by various experts about the study are given below:

1. Er. R.D. Singh suggested to develop isotope based empirical relations for forecasting of monsoon. He also informed that during his meeting with Sh. Ajit Tyagi, DG-IMD who expressed his willingness to collaborate with NIH on monsoon studies. To this Dr. Rao answered: isotope can predict arrival and departure of monsoon vapours and this data can be interlinked with meteorological equations to achieve the objective. He further stated that we need real time isotope data for proper monitoring of the monsoon vapours by using the online vapour analysis.
2. Dr. V.V. Rao and Dr. Kakade emphasized on establishing few more stations for understanding the regional dynamics of vapour. They also suggested to incorporate other meteorological conditions necessary for precipitation; such as cloud cover, integrated vertical moisture content, wind conditions etc. in interpretation of the data towards monsoon prediction.
3. Sh. Ritesh Arya appreciated the study and suggested need of such studies in advance warning of events such as cloud bursts or similar events in high altitudes of Himalayas. He advised to develop a few stations for isotope analysis in high altitude cold deserts or alpine areas like at Leh, where IMD observatory is available.

4. Dr. S.K. Singh, NIH suggested to identify the time required for vapours to travel between two NIH-IWIN stations and to use it in predicting the onset and withdrawal of monsoon.
5. Dr. B.P. Singh suggested to estimate onset and withdrawal dates of monsoon using δ^{18} O and δ D independently and to inter-compare these dates to confirm the validity of technique.

Study No. :NIH/HID/HP-II/09-12: **GROUNDWATER DYNAMICS OF BIST-DOAB AREA, PUNJAB USING ISOTOPES**

Dr. M. S. Rao presented the progress of the study. He started with the action taken on the comment of the 34th working group. The water quality data is presented using conventional methods (Piper, US-salinity, Wilcox, Gibbs and Gailardet et. al.) and explained its suitability for drinking and irrigation purposes. He informed that the sufficient number of stations have been established for isotopic characterization of water resources of the study area. On the basis of analysis of total 2230 samples, the characteristic of groundwater (shallow and deep), rain (plains and Kandi), river water (Beas and Satluj) and canals has been determined. It was also informed recharge to groundwater through seepage from canal is limited to a few tens of meters from the canal reach. A new concept based on environmental isotope (Tritium unit) fence diagram was presented and explained its significance in groundwater resource management. It was also informed that AWLRs (6nos.) were procured and installed in piezometers of Punjab Water Resources & Environment Directorate and the hourly water level data collected for the period of two months (17th August to 8th October, 2011) was shown during the presentation.

The experts gave the following comments on the study:

1. Dr. S.S. Grewal (Retd. Dir., PAU) informed that in the earlier studies based on Selenium concentration in groundwater it was shown that the canals contribute significantly to groundwater recharge from Balachaur to Nawanshahr and this aspect should be reconfirmed in the present study. In this regard, it was also stated that the canals have been lined recently. He also informed that groundwater is in rising conditions in Kandi area while rapidly declining in the central region of Bist-Doab. He asked to investigate this aspect using isotopic technique.
2. Dr. R.C. Jain, CGWB commented: the isotopic data indicated the deeper aquifers are in confined to sub-confined conditions that need to be substantiated using pump test and hydro-geological conditions.

Study No. :NIH/HID/FRI/08-13: **IMPACT ASSESSMENT OF LANDUSE ON THE HYDROLOGIC REGIME IN THE SELECTED MICRO-WATERSHED IN LESSER HIMALAYAS, UTTARAKHAND**

Dr. S. P. Rai presented the progress of the study. He informed that two watersheds namely, Arnigad and Bansigad near Mussoorrie have been selected for the study. Arnigad micro-watershed having as area of 3 km^2 is covered with dense oak forest while Bansigad micro-watershed having an area of 2 km^2 is covered with degraded mix forest of oak and pine. Both the watersheds are on the south facing hill slope. Highest and the lowest elevations of both the project area are approximately equal. Other morphometric parameters such as, relief ratio, stream order, form factor, and elongation ratio etc are almost same. Geology of the both the watershed

is same and the difference is only in land-cover. Dr. S. P. Rai informed that monthly average discharge in degraded watershed (Bansigad) vary between 0.01m^3/sec (minimum) in the month of November 1.02 m^3/sec (maximum) in the month August. The stream flowing through degraded watershed watershed becomes dry during the May and June. However, in forested watershed, it varies between 0.05 m^3/sec in the month of June and 0.88 m^3/sec in the month of August. It remains perennial throughout the year. Hydrograph analysis reveals that rainfall response on stream discharge of both watershed is very quick. However, the recession part of hydrograph differs to each other in both watersheds. The discharge decline slowly in Arnigad stream during post monsoon month while it declines at faster rate in Bansigad stream and stream become dry up in summer months. Monthly distributions of runoff in the both the micro watersheds vary significantly. During the monsoon period (June to September) of 2008-2009 and 2009-2010 runoff from the forested watershed is 45 to 60% and about 85% of the total discharge from Arnigad and Bansigad watershed respectively. Due to high runoff during the monsoon period, the Bansigad waterhed stream gets dry up during pre-monsoon months. The infiltration test conducted in different landuse condition reveals higher rate of infiltration in the dense oak forest cover. The analysis of soil moisture data revealed large variations in soil moisture storage at different sites and depths and also during different seasons in each of the watersheds. The profile analysis indicated highest soil moisture content in shallow profile which decreased with depth in both the watersheds. A high positive correlation was found between tree density and soil moisture content.

These results indicate that runoff is more uniform in case of dense forests. Runoff in both the catchments is maximum during August and minimum during the May. Total runoff in Bansigad during the month of August is 60% higher than that of Arnigad and from July to September, it is 48% higher than that of Arnigad. Runoff coefficient during the monsoon period, June to September is 0.39 and 0.61 for Arnigad and Bansigad micro watersheds, respectively. During post monsoon months, stream discharge from the degraded watershed reduces drastically. Discharge in Arnigad stream becomes higher than the Bansigad stream. Total runoff in Arnigad during the nonmonsoon period from October to March is 184mm (50%) more than that of Bansigad.

Dr. Rai also presented the analysis of the isotopic composition of rainfall, stream and springs. He informed that $\delta^{18}O$ of rain varies between minimum –21.2 ‰ in the month of September and maximum +2.6 ‰ in the month of June at Bansigad site and it varies between minimum –16.7 ‰ in the month of August and maximum +5.7 ‰ in the month of May at Arnigad site. He also presented the relations between δD and $\delta^{18}O$ developed for the study area. He informed that the slope and the intercept of the best fit line of both watershed are close to those of local meteoric water line for the Bhagirathi River basin. Regarding the isotopic composition of the stream water he mentioned that the depleted isotopic signature of stream discharge during the rainy months and enriched values during the pre-monsoon months reveal the seasonal variations due to change in source of contribution. During the monsoon months, stream discharge is dominated by surface runoff while during non rainy months, subsurface flow dominates. Recharge zone of two springs have been estimated using isotopic techniques.He also informed that rainfall-runoff and soil loss modelling will be carried out using SWAT model which is in progress.

Study No. :NIH/HID/INT/10-13: **STUDY OF VARIABILITY OF SNOW AND GLACIER CONTRIBUTION IN MELT WATER OF GANGOTRI GLACIER AT GOUMUKH USING ISOTOPIC TECHNIQUES**

Dr. S. P. Rai presented the progress of the study. He informed that sample collection for the ablation period is continued from 2010 at the site established by NIH, near Gangotri snout. Water sample of river and precipitation (rain/snow) have been collected on daily basis for analysis of stable isotopes (δD and δ^{18}O) and tritium. The analyses of the samples are in progress. River, precipitation and few snow and ice samples near Gaumukh snout have been collected during the previous years 2005, 2008 and 2007 and have been analysed for δD and δ^{18}O.

The isotopic signature of the fresh snow and surface ice samples collected near the snout ranges -4‰ to -13.9‰; and -13.3 to -18.5‰ respectively. The snow δ^{18}O values are enriched in comparison to that of glacier. The δ^{18}O values of river water during pre-monsoon (April to June) found between -12‰ and -13‰. The δ^{18}O values further depletes slowly in the month of July. The depleted δ^{18}O signatures continue in the remaining months of August and September with slight enrichment. The abrupt depletion of δ^{18}O in July, August and September is triggered with a heavy rainfall event. It has been observed that the isotopic values of river initially follow the δ^{18}O values of snow which indicate the snowmelt dominates in the river discharge at initial stage (during May and June).While, the depleted value of δ^{18}O in the months of July, August indicated more contribution from ice melt and snow of higher altitude.

The plot of δ^{2}H versus δ^{18}O for all precipitation samples collected during the ablation period of 2004 and 2008. The Local Meteoric Water Line (LMWL) developed as $\delta^{2}H = 8.2 (\pm 0.10) \times \delta^{18}O + 17.1 (\pm 1.53)$ (n = 15, r2 = 0.99) for a complete ablation period which is showing higher slope and y intercept in comparison to from the GMWL. δ^{2}H vs δ^{18}O plot for the meteoric water line developed for melt water of Gangotri Glacier at Gomukh site and the best fit line is $\delta^{2}H=8.2*\delta^{18}O + 18.97$ r^2 = 0.99, n = 110.

Dr. Rai informed about the progress made in hydrograph separation of snow and glacial melt contribution. The preliminary results reveal that contribution of snow melt dominates in the total discharge. Contribution of rainfall has been found about 3% of the total discharge during the 2005.

Study No.: NIH/HID/GBPIHED/10-13: **DEVELOPMENT OF SPRING SANCTUARIES IN AN URBAN AND A RURAL WATERSHED IN DISTRICT PAURI GARHWAL, UTTARAKHAND**

Dr. S. P. Rai presented the progress of the study. He informed that two watersheds have been identified for the study of spring sanctuaries which are facing with acute water scarcity. One water shed is in proper Pauri urban area and second one in the rural area i.e. Dugargad watershed. In Pauri watershed eight spring and in Dugargad watershed three spring have selected at different altitude to collect the water samples for stable isotopes (δD and δ^{18}O) radioactive isotope (^{3}H) analysis.

Meteorological observatory in both the the watershed has been installed to monitor the variation in meteorological parameters. The discharge of the springs has been measured on the daily basis during the monsoon period. The analysis of δD and $\delta^{18}O$ for collected spring and rainwater samples are in progeress. The plot of $\delta^{2}H$ versus $\delta^{18}O$ for rainfall samples collected during June to September 2010 show the Meteoric Water Line (spring) as $\delta^{2}H = 8.0 \times \delta^{18}O + 11.4$ which is similar to IMWL. The plot of $\delta^{2}H$ versus $\delta^{18}O$ for all springs samples collected during June to September 2010 show the Meteoric Water Line (spring) as $\delta^{2}H = 7.20 \times \delta^{18}O + 4.41$ which is very close to LMWL. These results indicate that source of these springs are local precipitation. The springs of Pauri urban area show depletion in the δD value of July month which indicate that there is quick response of recharge due to rainfall in the month of July. However, the δD of Dugargad watershed springs show no variation which is indicator of higher residence time of the springs. Dr. Rai informed that altitude effect have been estimated, which will be used to estimate the recharge zones of the spring.

The detailed geological and geomorphological map of the area was presented by Dr. Rai. Recharge zones of the springs have been project using the DEM and lineament details of the study area. The progress of the study was appreciated by Dr. Ritesh Arya and other members.

Study No.:NIH/HID/INT/10-12*:* **IDENTIFICATION OF RECHARGE ZONES OF SOME SELECTED SPRINGS OF UTTARAKHAND USING ISOTOPES**

Dr. Bhishm Kumar, Head, HID initially briefed the members about the study and briefly explained the isotopic techniques which is being followed for the study as methodology. He informed that the study has been referred by the Uttarakhand Jal Sansthan, as these springs have reported a significant reduction in their discharge in recent years. The study was then presented by Dr. S. D. Khobragade. He informed that the study has been taken up with the objectives of identifying the recharge zones of the springs and suggesting the remedial measures for their rejuvenation. Describing the study area, he informed that 4 springs namely Moli, Ratoli, Gothiyara and Kandha Dhangi falling in Chandrabhaga Watershed in Jakhanidhar Block of Tehri Garhwal district are being studied under the present investigations, as suggested by the Uttarakhand Jalsansthan. The study area terrain is highly rugged with steep slopes (elevation range: 800-2300 m). The geological formations are greenish grey slaty and schistose phyllite inter-bedded with quartzite. The soils are shallow and varying in texture and depth.

While discussing the progress of the study, he informed that daily rainfall data have been collected from 1 June-, 2010 and that about 500 water samples of springs, rain and GW have been collected and analyzed for deuterium and O-18. He also informed that spring discharge has been measured at 15 days interval for all the 4 stations since June-2010 and at weekly interval since June, 2011. Further he informed that the response of the springs to rainfall has been analyzed and it has been observed that all the four springs differ in their response which indicates different residence times of water for the various springs. He also informed that that correlation analysis between the spring discharge and lag series of rainfall carried out for Moli spring indicates a significant delay in the response of springs to rainfall. However, he clarified that the rainfall considered for such analysis is that of the

nearest station and since the spring may be recharged at a different altitude there may be some degree of error in such an analysis which can be rectified once the recharge altitude of the springs are established using the isotope techniques. He further informed that last year only three rainfall stations were established in the study area but this year four more additional rainfall stations have been established at different altitude to study the altitude effect. He informed that the local meteoric water line for the area has been developed and it has been observed that the local meteoric line falls exactly on the Indian Meteoric Water Line (IMWL). He also informed that the altitude effect for the study area has been studied using O-18 data. He told that using the O-18 data of the springs recharge altitude of Kandhadhangi spring has been estimated and for other springs, it is in progress. Discussing the work plan for the next two quarters he informed that the analysis of the data would be extended to identify the recharge altitude of the remaining springs. Then, based on this altitude as well as after the ground survey of the area, the recharge area would be identified after considering the hydro-geology and topography of the area. Once the recharge area is identified, recharge structures would be suggested.

Dr. B. P. Singh enquired whether the recharge altitude would be the same if del O-18 or del D data are used, Dr. Bhishm Kumar clarified that although the altitude effect would be different in case of del O-18 and del D, the recharge altitude would come out be the same.

Mr. Ritesh Arya, Chandigarh asked whether the discharge data and particularly the lean period discharge data, are being monitored or not. To this Dr. Khobragade informed that the discharge data are being continuously monitored for all the four springs at a weekly interval. However, he also clarified, that since no discharge measuring structures are available at these sites, a bucket is being used for the purpose and it has a limitation of recording the maximum discharge.

Study no. :NIH/HID/INT/11-13/1: **ASSESSMENT OF RADON CONCENTRATION IN WATERS AND IDENTIFICATION OF PALEO-GROUNDWATER IN PUNJAB STATE**

Sh. S.K Verma, the principal investigator of the study, presented the study before the members of the WG meeting. He mentioned about the objectives of the study along with the location of study area, action plan, end users/beneficiaries, equipment procured etc. He also mentioned about the actions taken on the suggestions raised during the last working group meeting.

While discussing the progress of the study, he informed that much progress has not been made during last two quarters because the required instrument i.e. radon detector was supplied and installed by the agency during the month of Aug. 2011. After that rigorous testing of the instrument was carried out in the Nuclear Hydrology laboratory. In the mean time, a lot of literature were collected regarding the radon concentration measured in different parts of India. He also informed that as suggested by one of the honorable members of the last working group, a field trip was organized to collect water samples from different sources from different locations from nearby areas of Narora Atomic Power plant. Accordingly a total of 7 water samples were collected from different sources and different locations near Narora and radon concentration were measured in these samples. In addition to that

three water samples were also collected from hand pump, tube well and Ganga canal water from Roorkee. These samples were also analysed for radon concentration. The radon concentrations measured in these samples were within the maximum permissible limit as per the guide lines of WHO.

Study no. :NIH/HID/INT/11-13/2: **HYDROLOGICAL ASSESSMENT FOR ARTIFICIAL RECHARGE AND WATER MANAGEMENT IN GHAR AREA, SAHARANPUR DISTRICT, U.P.**

The study was presented by Sh. Pankaj Garg, Scientist B. He informed that this study has been taken up with the objectives to identify the groundwater recharge zones and groundwater flow velocity for Ghar area and to identify sites for water harvesting structures in Ghar area which is water scares. He further informed that the two blocks of district Saharanpur which fall in Ghar area namely, Muzaffarabad and Sadhauli Kadim have been selected for this study. He said that 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. Presently, both the blocks fall in dark category and require artificial recharge measures. Discussing about the study area, he informed that the area of the Muzaffarabad block is 40621 ha and Sadhauli Kalim block is 38767 ha. There are total 130 Govt. tubewells and 5333 private tubewells and pumping sets in Block Muzaffarabad while only 6 Govt tubewells and 4196 private tubewells and pumping sets are available in Block Sadhauli Kadim which draw groundwater for meeting out the drinking and irrigation needs. He further discussed about the progress of the works carried out during the last six months. He informed that water samples were collected from 34 sites for water chemistry and isotope analysis. A total of 16 sites were finalized for further collection of water samples. The isotopic analyses of collected water samples have been completed in the Nuclear Hydrology laboratory. He informed that the further interpretation of the hydrological and isotopic data is in progress.

Study No. :NIH/HID/CONS/11-13: **INTEGRATED HYDROLOGICAL INVESTIGATIONS OF SUKHNA LAKE, CHANDIGARH FOR ITS CONSERVATION AND MANAGEMENT**

The study was presented by Dr. S. D. Khobragade, Sc-E1 and PI. He informed that it is a consultancy project given by the Chandigarh Administration through the Conservator of Forests, Chandigarh and has started since July, 2011. Discussing the study area he informed that Sukhna Lake is a very significant lake of Chandigarh because of its being an important tourist attraction and centre of recreation. Discussing the major problems of the lake he informed that the lake is reported to be facing a serious threat of sedimentation. Its capacity has been reported to have decreased significantly in the past few decades. At the time of its construction its storage capacity was 10.74 MCM. It has now been reported that more that 60% of the original storage capacity has been lost and that about 40 % reduction in the water spread area of the lake has taken place within the first three decades after its construction. Moreover, water levels in the lake have been observed to go down considerably in some of the recent years. Also, presence of underground weeds is being observed in the lake in recent years which needs to be curbed. Thus, he stressed the need to conserve the lake for future. However, he also

out that although some scattered studies have been reported on the assessment of sedimentation in the lake, no systematic and scientific hydrological investigations have been reported for the lake. He informed that the major objectives of the study are (i) To estimate water availability in the lake through systematic assessment of the water balance components of the lake, (ii) To estimate sedimentation rate and expected life of the lake, (iii) To study the water quality of the lake and (iv) To suggest measures for conservation and management of the lake, based on the investigations. Discussing the progress of the work carried out in the last three months, he informed that A number of field visits have been made and since no historical data for the lake site are available, instruments such as ordinary raingauges, automatic raingauges, AWLR and AWS have been installed in the study area and data are being collected. He also informed that gauges have been installed in the inflow channel for discharge estimation. He also informed that digital elevation map and drainage map of the study area have been prepared and that samples of rain water, ground water and lake water are being continuously collected for isotopic analysis as well as data on lake water levels and ground water levels are being monitored. He also briefly presented the analysis of the water level data of the lake obtained so far and also discussed the crude estimate of the inflow regime obtained using the collected data and said that from the preliminary analysis it appears that surface abstraction in the catchment appears to be a major reason for the reduced inflow to the lake. However, he said that detailed analysis needs to be carried out before arriving at any conclusions. Dr. Bhishm Kumar informed that a number of earthen and masonry dams have been constructed in the catchment area which are abstracting water in the catchment.

Reacting on the results of the preliminary analysis presented by Dr. Khobragade, Dr. Grewal, SPACE, Chandigarh, said that the present analysis is still very preliminary. He further commented that the role of the check dam should not be viewed separately or only from the angle of their role in surface abstraction but their significant role in controlling the siltation should also be taken into account. Dr. Khobragade clarified that this is just a preliminary analysis carried out to understand the hydrological regime independently and also said that he does agree to the views expressed by Dr. Grewal and informed that integrated role of the check dams would be studied once all the data are available.

SURFACE WATER HYDROLOGY DIVISION

Dr. Jaivir Tyagi, Scientist F, Surface Water Hydrology Division presented brief details of various studies being carried out under the 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. SNOW MELT RUNOFF MODELLING IN SUTLEJ BASIN

Dr. A. R. Senthil kumar, PI of the project, presented the objectives, methodology, and results of the study in brief. Dr M Perumal, Professor, DOH, IIT, Roorkee enquired about the input data to the ANN Models and the application of conceptual models in simulating the snow melt runoff. The PI of the study informed about the input data of the ANN model and the application of conceptual models SNOWMOD and SRM for the simulation. Sh Kishore Kumar asked about the length of the data used in the study. The PI informed about that the

data up to 2003 was used and the inability of the consideration of the updated data beyond 2003 due to non availability of the snow covered area. The chairman of the working group suggested to present complete work in the next working group meeting.

2. 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 part of the report consisting snow cover mapping which would be an input to the snowmelt runoff model in the second part of the study has been completed. She further informed that precipitation and temperature data for the study area has also been processed elevation band wise. She further presented the area-elevation relationships prepared from the DEM of the basin and informed that various other input data are being prepared to calibrate the SNOWMOD program which would be completed by end of March 2011 as per the study program. Sh. R.K. Yadav, Member of the working group enquired how impact of climate change would be studied. Mrs Sarkar informed that the snowmelt runoff model, namely, SNOWMOD contains precipitation and temperature as input and once the model is calibrated, various scenarios of precipitation and temperature would be applied to study the impact of climate change on runoff of the basin.

3. MONITORING AND MODELLING OF STREAMFLOW FOR THE GANGOTRI GLACIER

Dr Arora presented the progress of the study. He informed the house that the data collection for the ablation period of 2011 was started in the month of May. He presented the results of the data collected during the winter 2010. The maximum temperature varied between 16.3°C to -6.3°C whereas the minimum temperatures varied between 3.1°C to -17.8°C. The discharge was observed for the winter season first time and it has been observed that the discharge varied between 4.4 to 14.9 m^3/s. There were no specific comments from the members.

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

Dr Arora presented the progress of the study. He presented the results of the downscaled output of the data for precipitation for the period 1980 to 2000 for the Satluj basin. He informed that the data downloaded will be compared with the observed data and the bias correction will be done. The same procedure will be repeated for the temperature. There were no specific comments from the members.

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

Dr. Manohar Arora presented the objectives of the study and explained the reasons for undertaking the study. Study area, and methodology were presented in brief. Study progress was presented with updated data and spring flow lag to rainfall on daily and monthly basis. The Chairman suggested that one of the objectives must reflect the Climatic variability analysis and its impact on watershed and be amended.

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

The study was presented by Dr. S.K. Jain, Sc. 'F'. He explained the objectives of the study along with the progress made so far. He explained that the procurement of IRS data is in process and data of 2010 and 2011 will be used for identification of glaciers and lakes etc. In the mean time Landsat TM data is being used for identification of lake and glacier. Dr. R K Goyal enquired about the significance of climate change in the study. Dr. Jain replied that there are some glaciers which are retreating due to climate change and that aspect will be studied. Mrs. Vijay Luxmi asked about the technique of glacier mapping and how it is different from technique applied by ICIMOD. Dr. Jain said that the techniques applied by ICIMOD are followed in the present study and also SVM approach will be applied for glacier mapping. Director asked about the design flood/100 return flood. Dr. Jain said that in this study routing of Lake Burst flood will be carried out taking into account 100 year return flood available at the outlet of the basin. Dr. Perumal enquired about the model to be used for GLOF studies. Dr. Jain informed that MIKE 11 will be used for this purpose.

7. HYDROLOGICAL STUDIES FOR UPPER NARMADA BASIN

Mr. Jagadish Prasad Patra, Sc B presented the study. The objectives of the study with brief methodology and data collected for this study were discussed. Some of the initial results like estimation of design flood were presented. Prof. M. Perumal appreciated the efforts and suggested to try available runoff-volume models in HEC-HMS. Mr. Jagdish Patra informed that the presented results are initial results and the process of carrying out rainfall runoff modelling with the collected data is in progress. Prof. K.C. Patra enquired about possibilities of validating flood inundation maps with remote sensing images.

WATER RESOURCES SYSTEM DIVISION

S. N.	Title of the Project/Study, Study Team, and Start and Completion Dates	Status, and Recommendation/suggestion
	Research studies	
1.	Application of a distributed hydrological model for river basin planning and management M. K. Goel (PI), Vijay Kumar (on lien), D. S. Rathore, Deepa Chalisgaonkar, and Rama Mehta DOS: 10/2009; DOC: 3/2012	Ongoing study (Research study) Dr. M. Perumal suggested that the results of the MIKE Basin will be better than the results of the HEC-HMS model. Mrs. Deepa informed that the results of the NIH model will be compared with other models bringing out the advantages/limitations of distributed models in comparison to the semi-distributed models.
2.	Web based information system for major and important lakes in India Deepa Chalisgaonkar (PI), and Suhas Khobragade DOS: 04/2010; DOC: 3/2012	Ongoing study (Research study) 1. On inquiry from Mrs Laxmi Smt. Deepa informed that - Reference to source of information is being provided wherever required. - Information is being collected only from documented sources and websites and not from field. - Efforts would be made to update the system from time to time with the availability of new information. 2. Sh. Kishor Kumar suggested - to-include/ refer-to the GIGB

		guidelines given by the Govt for the security of the websites; and - to include/provide in the system the information about RRR and a two-way link to the information and updates from the Ministry's and CWC's sites maintaining such details. Smt Deepa Chalisgaonkar informed that the Computer Centre of NIH will be maintaining the website, which will be requested for doing the needful regarding the GIGB guidelines once the fully developed system is handed over to the Computer Centre. 3. Dr. M. Perumal Perumal suggested considering the information on lakes prepared by Sunita Narayan. 4. On inquiry from Sh. M. Krishna Rao it was informed by Smt Chalosgaonkar and Dr. Khobragde that -The system is not a GIS based system. -Besides multiple modern dams, other water bodies which are significant and for which information is available are being considered for the system.
3.	Analysis of water management scenarios in Tapi River basin using MIKE Basin Rama Mehta (PI), M. K. Goel, and D. S. Rathore DOS: 04/2010; DOC: 3/2013	Ongoing study (Research study) No specific comment/suggestion.
4.	Development of analytical equation for alternate depths for flow in rectangular channels Sushil K. Singh DOS: 4/2011; DOC: 3/2012	Ongoing study (Research study) Dr. M. Perumal enquired about the difference between the intended solution and that given in the book by Subhash. Dr. S. K. Singh informed that intended solution would be a generalized one and both alternate depths can be obtained from the known value of the specific energy.
5.	A transfer function model for event based runoff Sushil K. Singh DOS: 4/2011; DOC: 3/2012	Ongoing study (Research study) No specific comment/suggestion.
6.	Trend and variability analysis of Rainfall and Temperature in Himalayan region L. N. Thakural (PI), Sanjay Kumar, Sanjay K. Jani, and Tanveer Ahmed DOS: 10/2011; DOC: 09/2014	New study (Research study) No specific comment/suggestion.
7.	Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin Sanjay K. Jain (PI), Bhism Kumar, S. P. Rai, and L. N. Thakural DOS: 04/2009; DOC: 03/2012	Ongoing study (PDS under HP-II) No specific comment/suggestion.
8.	Assessment of effects of sedimentation on the	Ongoing study (PDS under HP-II)

	capacity/ life of Bhakra Reservoir (Gobind Sagar) on River Satluj and Pong Reservoir on River Beas Sanjay K. Jain (PI), J. V. Tyagi, L. N. Thakural, and Rama Mehta DOS: 04/2009; DOC: 03/2012	On suggestion from Dr. Grewal, Dr. S. K. Jain informed that the work at Largi in Beas basin for soil erosion will be consulted for the present study.
9.	Hydrological assessment of ungauged catchments (small catchment) Pradeep K Bhunya (PI), Rakesh Kumar, D. S. Rathore, Sanjay Kumar, P. C. Nayak DOS: 05/2009; DOC: 05/2012	Ongoing study (PDS under HP-II) No specific comment/suggestion.
Consultancy projects		
10.	Vetting of water availability studies of the Gulf of Khambhat Development Project (Kalpasar Project) M. K. Goel, Vijay Kumar (on lien) DOS: 04/2011; DOC: 10/2011	Ongoing study
11.	Glacier Lake Outburst Flood (GLOF) study for Jelam tamak (THDC India Ltd.) Sanjay K. Jain, A. K. Lohani, L. N. Thakural, Anju Chaudhary, and Tanveer Ahmed	Ongoing study
12.	Snowline estimation, snowmelt runoff study and Glacial Lake Outburst Flood study for Chamkharchhu H.E. Project in Bhutan (NHPC, Faridabad) Sanjay K. Jain, A. K. Lohani, L. N. Thakural, and Anju Chaudhary	Completed
13.	Snowline estimation snowmelt runoff study and Glacial Lake Outburst Flood study for Kuri-Gongri H.E. Project in Bhutan (NHPC, Faridabad) Sanjay K. Jain, A. K. Lohani, Sudhir Kumar, L. N. Thakural, Anju Chaudhary, and Tanveer Ahmed	Completed

RESEARCH COORDINATION & MANAGEMENT UNIT (RCMU)

SN	Title of the Project/Study, Study Team & Duration	Recommendations/suggestions
1	Recession Flow Analysis for Evaluation of Spring Flow in Indian Catchments Team : Ravindra V. Kale (PI), V. C. Goyal DOS: Apr 2011 DOC: Mar 2013	No specific comment/suggestion.

The Working Group noted the progress of the studies undertaken and recommended the new studies initiated by different Divisions of the Institute.

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 participants of the 35th Working Group Meeting

1	Shri R.D. Singh Director, NIH	**Chairman**
2	Prof. J S Rawat, Kumaon University, Almora	Member
3	Dr R Krishnan, IITM, Pune	Member
4	Shri R C Jain, CGWB, Dehradun	Member
5	Dr M P Singh, FRI, Dehradun	Member
6	Dr Kishore Kumar, NIC, New Delhi	Member
7	Shri A K L Asthana, WIHG, Dehradun	Member
8	Dr M Perumal, IIT Roorkee	Member
9	Dr R K Goyal, CAZRI, Jodhpur	Member
10	Dr V V Rao, NRSC, Hyderabad	Member
11	Er Ravindra Kumar, SWARA, Lucknow	Member
12	Dr G P Juyal, CSWCRTI, Dehradun	Member
13	Shri Niladri Naha, SWID, Kolkata	Member
14	Er D K Singh, UJS, Dehradun	Member
15	Shri B M M Krishna Rao, GWD, Hyderabad	Member
16	Er N K Sharma, IRI, Roorkee	Member
17	Prof K C Patra, NIT Rourkela	Member
18	Dr A P Singh, BITS Pilani	Member
19	Dr S S Grewal, Chandigarh	Member
20	Dr Ritesh Arya, Chandigarh	Member
21	Dr Ravi Chopra, PSI, Dehradun	Member
22	Dr (Mrs) Vijayalakshmi, DA, New Delhi	Member
23	Shri Bharat Kakade, BAIF, Pune	Member
24	Dr A J James, Gurgaon/New Delhi	Member
25	Shri R M Bhardwaj, CPCB, New Delhi	Member
26	Prof. B.P. Singh, Gurgoan	Invitee
27	Dr. Bhishm Kumar, Head, HI Division, NIH	Member
28	Dr. V K Choubey, Head, EH Division, NIH	Member
29	Dr. N.C. Ghosh, Head, GWH Division, NIH	Member
30	Dr. V. C. Goyal Scientist F & Head, RCMU, NIH	Member-Secretary

Scientists from National Institute of Hydrology, Roorkee

1. Dr. S.K. Singh, Sc.F
2. Shri C.P. Kumar, Sc. 'F'
3. Dr. Sanjay Kr. Jain, Sc.F
4. Dr. J.V. Tyagi, Sc.F
5. Dr. Sudhir Kumar, Sc.F
6. Smt. Deepa Chalisgaonkar, Sc.F
7. Shri Omkar Singh, Sc.E2
8. Dr S.D. Khobragade, Sc.E1
9. Dr. S.P. Rai, Sc.E1
10. Dr A R Senthil Kumar, Sc.E1
11. Shri S K Verma, Sc. C
12. Smt. Archana Sarkar, Sc.C
13. Shri A K Dwivedi, Sc. C
14. Dr. M.K. Sharma, Sc.C
15. Shri Pankaj K. Garg, Sc.B
16. Dr Ravindra Kale, Sc. B
17. Shri J P Patra, Sc. B
18. Shri Sumant Kumar, Sc. B
19. Dr Rajesh Singh, Sc. B
20. Shri L N Thakral, Sc. B
21. Shri T R Nayak, Sc. E1-RC Sagar

ANNEXURE-II

Approved Work Program of Different Divisions for the Year 2011-12

ENVIRONMENTAL HYDROLOGY DIVISION

SN	Study	Team	Duration
	Internal Studies		
1	Spatial Variability of Ground Water Quality in Kandi, Sirowal and Shiwalik Belts of Jammu Region, J&K (India)	Omkar Singh (PI), V K Choubey, D.G. Durbude, M K Sharma	DOS: Apr 2010 DOC: Mar 2011 Revised DOC: Sep 2011
2	Environmental Flow Requirement of a River: A case study of Hemavathi River	Dilip G. Durbude (PI), V.K. Choubey, Omkar Singh, M.K. Sharma	DOS: Oct 2009 DOC: Sep 2012
3	Development of low cost media for fluoride removal from drinking water of fluoride affected areas	Rajesh Singh (PI), V K Choubey, Omkar Singh, M K Sharma	DOS: Apr 2011 DOC: Mar 2013
4	Assessment of Groundwater Quality in Hindon River Basin	M.K. Sharma, V. K. Choubey, Omkar Singh, Rajesh Singh	3 Years **(New Study)**
	Sponsored Projects		
5	Assessment of Ground Water Quality in Class I Cities in India - Phase II	V.K. Choubey, M.K. Sharma	DOS: Oct 2008 (Ph-I), Apr 2010 (Ph-II) DOC: Mar 31, 2011 (extended upto Oct, 2011)
6	Impact of sewage effluent on drinking water sources of Shimla city and suggesting ameliorative measures	V.K. Choubey (PI), R.P. Pandey, Omkar Singh, D.G. Durbude, M.K. Sharma, Rajesh Singh	DOS: Apr 2009 DOC: Mar 2012

GROUNDWATER HYDROLOGY DIVISION

Reference Code	Study	Team	Duration	Funding Source
	Internal Studies			
1. NIH/GWD/NIH /09-12/	Impact of Climate Change on Dynamic Groundwater Recharge in a Drought Prone Area	Surjeet Singh (PI) C.P. Kumar Anupma Sharma Rajan Vatsa	3 years (04/09– 03/12)	NIH
2. 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)	NIH
3. NIH/GWD/NIH /11-14	Groundwater Fluoride Contamination in different parts of India and study severity of Fluorosis in a Drought prone area	A.K. Dwivedi (PI) N.C. Ghosh, Anupma Sharma, Sumant Kumar, Sanjay Mittal, Ram Chandra	3 years (04/11– 03/14)	NIH
4. NIH/GWD/NIH	Management of Aquifer Recharge (MAR) and	Sumant Kumar (PI) Rajan Vatsa, N.C.	3 years (04/11– 03/14)	NIH

/11-14	Aquifer Storage Recovery (ASR)	Ghosh, C.P. Kumar, Surjeet Singh, Sanjay Mittal		
Sponsored Projects				
5. 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, A.D. Gohil, C.K. Jain, Sudhir Kumar, D.S. Rathore, Surjeet Singh, Rajan Vatsa	3 years (10/09– 06/12)	PDS (HP-II)
6. 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: Bhishm Kumar, V. C. Goyal, C. K. Jain, Sudhir Kumar, B. Chakravorty, A. K. Lohani , Anupma Sharma, Surjeet Singh, Sumant Kumar	36 months (Oct, 2011-Sep,2014)	European Union
Consultancy Projects				
7.	Feasibility study of surface water and groundwater availability including identification of potential groundwater recharge sites in the CIFMR campus, Dhanbad		6 months w.e.f. August, 2011.	Engg. Projects (India) Ltd.

HYDROLOGICAL INVESTIGATIONS DIVISION

Reference Code	Study	Team	Duration/ Status
Internal Studies			
NIH/HID/INT/09-12	SW and GW Interaction at Selected Locations Along River Yamuna in NCT, Delhi: Phase-II	Sudhir Kumar (PI) M. S. Rao P. K. Garg	3 years *(4/09 –3/12)*
NIH/HID/INT/10-13	Study of Variability of Snow and Glacier Contribution in Melt Water of Gangotri Glacier at Goumukh using Isotopic Techniques	S.P. Rai (PI) Manohar Arora, Bhishm Kumar, Rakesh Kumar and Naresh Kumar	3 years *(4/10–3/13)*
NIH/HID/INT/10-12	Identification of Recharge Zones of Some Selected Springs of Uttarakhand Using Isotopes	S. D. Khobragade (PI) Bhishm Kumar, Sudhir Kumar, S. P. Rai, Pankaj Garg + Uttarakhand Jal Sansthan	*2 years (04/10-03/12)*
NIH/HID/INT/11-13/1	Assessment of Radon Concentration & Identification of Paleo Groundwater in	S K Verma (PI), Sudhir Kumar M S Rao, Bhishm Kumar	*2 years (04/11-03/13)*

Reference Code	Study	Team	Duration/ Status
	Punjab State		
NIH/HID/INT/11-13/2	Hydrological Assessment for Artificial Recharge and Water Management in Ghar Area, Saharanpur District, U.P.	P.K.Garg (PI), Sudhir Kumar, Tanveer Ahmad, Rajesh Agarwal, V C Goyal, Bhishm kumar	*2 years (04/11-03/13)*

Sponsored Projects				
NIH/HID/DST/07-12	National programme on isotope fingerprinting of waters of India (IWIN)	M.S. Rao (PI), B. Kumar, Sudhir Kumar, S.P. Rai, S.K. Verma, Pankaj Garg + other 13 organizations	5 years *(07/07–06/12)*	DST
NIH/HID/FRI/08-13	Impact Assessment of Landuse on the Hydrologic Regime in the selected Micro-watersheds in Lesser Himalayas, Uttarakahand	S.P. Rai (PI) Bhishm Kumar J.V. Tyagi	5 years *(04/08–03/13)*	FRI
NIH/HID/GBPIHED/10-13	Development of Spring Sanctuaries in an Urban and Rural Watershed in District Pauri Garhwal, Uttarakhand	Dr. S.P. Rai (PI), Bhishm Kumar, Sudhir Kumar, Suhas Khobragade, Pankaj Garg	3 years *(04/10-03/13)*	GBPIHED
NIH/HID/HP-II/ 09-12	Groundwater Dynamics of Bist-Doab Area, Punjab Using Isotopes	M.S. Rao (PI), Bhishm Kumar, Sudhir Kumar, S.K. Verma, PankajGarg +CGWB Officials	3 years *(07/09-6/12)*	HP-II
NIH/HID/HP-II/ 09-12	Groundwater Management in Over- Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka	Sudhir Kumar (PI), J.V. Tyagi, Vijay Kumar, B.K. Purandara, S.P. Rai, M.S. Rao + DMG, Karnataka	3 years *(07/09-6/12)*	HP-II
NIH/HID/CONS/11-13	Integrated Hydrological Investigations of Sukhna Lake, Chandigarh for its Conservation and Management	S. D. Khobragade (PI) S. P. Rai Bhishm Kumar Vipin Agrawal, SRA	2 years (07/11-6/13) **New study**	Forest dept. Chandigarh

Consultancy Projects				
NIH/HID/DJB/10-11	Assessment of Groundwater Resources & Development Potential of Yamuna Flood Plain, NCT, Delhi	Sudhir Kumar (PI) Vijay Kumar + IITD,DU,CGWB, IARI, CWC,DJB	1 year *(02/10-01/11)* **(Consultancy)**	Delhi Jal Board
NIH/HID/RSMML/JKT/10-12	Hydrogeological studies of Jhamarkotra Mines, Udaipur, Rajasthan	Sudhir Kumar (PI), M.S.Rao, S.K. Verma, Pankaj Garg	1.5 years *(07/10-12/11)* **(Consultancy)**	RSMML, Udaipur

SURFACE WATER HYDROLOGY DIVISION

Ref. Code	Study	Team	Duration
Internal Studies			
1. NIH/SWD/NIH/08-12	Study on integrated water resources management of sub-basin to cope with droughts	R.P. Pandey, Ravi V. Galkate, Surjeet Singh, L.N. Thakaral	4 years
2. NIH/SWD/NIH/09-12	Snow Melt Runoff Modelling in Sultej Basin	A.R. S. Kumar, Manohar Arora, A. Agarwal, D.S.Rathore, Digambar Singh	3 years
3. 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
4. NIH/SWD/NIH/08-	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora, Rakesh Kumar	To be continued
5. NIH/SWD/NIH/10-13	Climatic Scenarios Generation for Satluj Basin using Statistical Downscaling Techniques	Manohar Arora, Rakesh Kumar	3 years
6. NIH/SWD/NIH/09-11	Data book - hydro-meteorological observatory 2001-2008	Digambar Singh, A. R. S. kumar, Manohar Arora	2 years (up to Sept. 2011)
7. 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
8. 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
9. NIH/SWD/NIH/11-14	Hydrological Studies for Upper Narmada Basin.	Jagdish P. Patra, Rakesh Kumar, Pankaj Mani, T R Sapra	3 years

WATER RESOURCES SYSTEMS DIVISION

S.N.	Study	Team	Duration
Internal Studies			
1.	Application of a distributed hydrological model for river basin planning and management	M.K. Goel, Vijay Kumar, D.S. Rathore, D. Chalisgaonkar, Rama Mehta	2 yr 6 month (10/09-3/12)
2.	Web based Information System for Major and important Lakes in India	D. Chalisgaonkar, Suhas Khobragade	1 year (4/10-3/12)
3.	Analysis of water management scenarios in Tapi River basin using MIKE Basin	Rama Mehta (PI), M.K. Goel, Vijay Kumar/D.S. Rathore	3 years (4/10-3/13)
4.	Development of analytical equation for alternate depths for flow in rectangular channels	S.K. Singh	1 year (4/11-3/12)

5.	A transfer function model for event based runoff	S.K. Singh	1 year (4/11-3/12)
6.	Trend and variability analysis of Rainfall and Temperature in Himalayan region	L.N. Thakural, Sanjay Kumar, Sanjay Kumar Jain, Tanveer Ahmad	3 years (10/11-9/14) **New Study**
Sponsored Projects			
7.	Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin	Sanjay K. Jain, Bhishm Kumar, Vijay Kumar, S.P. Rai, Renoj Theyyan	3 Years (4/09 – 3/12)
8.	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, D.S Rathore, L.N. Thakural, Rama Mehta	3 Years (4/09-3/12)
9.	Hydrological Assessment of Ungauged Catchments (Small Catchment)	P.K.Bhunya (PI), Rakesh Kumar, D.S. Rathore, Sanjay Kumar, P.C. Nayak	2 Years (5/09-5/12)
Consultancy Projects			
10.	Vetting of Water Availability studies of the Gulf of Khambhat Development Projects (Kalpasar Project)	M.K. Goel Vijay Kumar	6 Months (4/10-12/11)
11.	Glacier Lake Outburst Flood (GLOF) study for Jelam tamak (THDC India Ltd.)	Sanjay K Jain, AK Lohani, L N Thakural, Anju Chaudhary, Tanvear Ahamd	
12	Snowline estimation, snowmelt runoff study and Glacial Lake Outburst Flood study for Chamkharchhu H.E. Project in Bhutan (NHPC, Faridabad)	Sanjay K Jain, A. K. Lohani, L. N. Thakural, Anju Chaudhary	
13	Snowline estimation snowmelt runoff study and Glacial Lake Outburst Flood study for Kuri-Gongri H.E. Project in Bhutan (NHPC, Faridabad	Sanjay K Jain, A K Lohani, Sudhir Kumar, L N Thakural, Anju Chaudhary, Tanvear Ahamd, PRA	

RESEARCH COORDINATION & MANAGEMENT UNIT (RCMU)

SN	Study	Team	Duration
Internal Studies			
1	Recession Flow Analysis for Evaluation of Spring Flow in Himalayan Region, India	R. V. Kale (PI), V. C. Goyal	DOS: Apr 2011 DOC: Mar 2013

ANNEXURE – B

Division-wise Work Programme

ENVIRONMENTAL HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr V K Choubey	Scientist F & Head
2	Sri Omkar Singh	Scientist E2
3	Dr Mukesh Sharma	Scientist C
4	Dr Rajesh Singh	Scientist B
5	Smt Babita Sharma	RA
6	Smt Bina Prasad	RA

WORK PROGRAMME FOR THE YEAR 2011-2012

S.No.	Study	Study Team	Duration
	Internal Studies		
1.	Assessment of Groundwater Quality in Hindon River Basin	M.K. Sharma, V. K. Choubey, Omkar Singh, Rajesh Singh, Babita Sharma, Beena Prasad, Rakesh Goel, Dayanand	3 Years (11/2011-10/2014)
2.	Development of low cost media for fluoride removal from drinking water of fluoride affected areas.	Rajesh Singh, V. K. Choubey, Omkar Singh, M.K. Sharma, Dayanand	2 Years (4/2011-3/2013)
3.	Spatial Variability of Ground Water Quality in Jammu, Kathua and Udhampur Districts, J&K (India)	Omkar Singh, V K Choubey, M K Sharma	1 year 6 months (4/2010-9/2011)
	Sponsored Projects		
4.	Impact of sewage effluent on drinking water sources of Shimla city and suggesting ameliorative measures	V.K.Choubey, Omkar Singh, M.K. Sharma, Rajesh Singh, I&PHE Dept. Shimla	3 years (4/2009-3/2012)
5.	Assessment of Ground Water Quality in 25 Class I Cities of India – Phase II (Chandigarh, Panjim, Gandhinagar, Shrinagar, Ranchi, Thiruvananthapuram, Imphal, Pondicherry, Kavaratti, Daman, Silvassa, Ratlam, Bilaspur)	V.K. Choubey, M.K. Sharma, Babita Sharma, Beena Prasad, Rakesh Goel, Dayanand	2 year 6 months (4/2009-10/2011)

PROPOSED WORK PROGRAMME FOR THE YEAR 2012-2013

S.No.	Study	Study Team	Duration
Internal Studies			
1.	Assessment of Groundwater Quality in Hindon River Basin	M.K. Sharma, V. K. Choubey, Omkar Singh, Rajesh Singh, Babita Sharma, Beena Prasad, Rakesh Goel, Dayanand	3 Years (11/2011-10/2014)
2.	Development of low cost media for fluoride removal from drinking water of fluoride affected areas.	Rajesh Singh, V. K. Choubey, Omkar Singh, M.K. Sharma, Dayanand	2 Years (4/2011-3/2013)
3.	Water Quality Modeling of Hindon River	Omkar Singh, V. K. Choubey, M.K. Sharma, Rajesh Singh, A.R. Senthil Kumar, Babita Sharma, Beena Prasad, Rakesh Goel, Dayanand	3 years (4/2012-3/2015) New Study

Study – 1

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

2. **Study Group:**

Project Investigator Dr. M. K. Sharma, Scientist 'C', NIH
Co-Investigators Dr. V. K. Choubey, Scientist 'F' / Head, EHD Shri Omkar Singh, Scientist 'E2 Dr. Rajesh Singh, Scientist 'B', NIH
Scientific/Technical Staff Smt. Babita Sharma, RA, Smt. Beena Prasad, RA Sri Rakesh Goel, Sr. Technician Sri Dayanand, Technician 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:**
   - Monitoring and assessment of water quality of Hindon river
   - Examine the suitability of ground water in the vicinity of river Hindon for various designated uses
   - Characterize different point sources contributing river Hindon
   - Explore possible remedial measures for improvement of river water quality

9. **Statement of 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 (Sharma, 2001; Ali, 2000). These toxic pollutants will ultimately reach the groundwater and will enter in the food chain posing a threat to human health because of their carcinogenic nature. In view of

these facts, assessment of the present status of surface 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

11. Timeline:

Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
2011-12	-	-	Literature Survey	Reconnaissance Survey of the study area
2012-13	Field visit, Sampling & Analysis	Field visit, Sampling & Analysis	Field visit, Sampling & Analysis	Analysis and processing of the data
2013-14	Field visit, Sampling & Analysis	Field visit, Sampling & Analysis	Field visit, Sampling & Analysis	Analysis and processing of the data
2014-15	Analysis and processing of the data	Writing of the Report	-	-

12. Objectives and achievement during last six months

Objectives	Achievements
Literature Survey & Reconnaissance Survey	Extensive literature survey for surface water and groundwater quality in Hindon river basin was carried out and a reconnaissance survey of Hindon river basin was made in the month of February 2012 and collected surface water samples and groundwater samples.

13. Recommendation / Suggestion

Recommendation / Suggestion	Action Taken
Sri Ritesh Arya suggested to collect ground water samples from different depths to have proper picture of the study area.	Groundwater samples are being collected from different depths from the same locations

14. Analysis & Results

An extensive literature survey indicates that few studies have been carried out on groundwater quality of some specific areas in the Hindon river basin covering only the physico-chemical aspects. Bacteriological, metal and pesticide aspects will be covered in the present study. A reconnaissance survey of Hindon river basin was made in the month of February 2012 and collected few representative samples from surface water and groundwater. Analysis of collected samples for Physico-chemical parameters, Bacteriological parameters, Toxic (Heavy) Metals and Organo-chloro Pesticides 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 **:** Paper & Report

17. Major items of equipment procured **:** None

18. Lab facilities used during the study **:** Water Quality Laboratory

19. Data procured or generated during the study: None

20. Study Benefits / Impacts

Measurable indicators	Achievements
i) Groundwater quality and surface water quality data	In progress
ii) Identification and characterization of point sources	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:

- Collection & analysis of surface and groundwater quality samples
- Characterization of point sources pollution
- Identification of degraded water quality locations and degraded stretches of river Hindon
- Processing of data to examine the suitability for different designated uses.

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, Scientist 'B', NIH
Co-Investigators: Dr. V. K. Choubey, Scientist 'F'/Head, EHD, Shri Omkar Singh, Scientist 'E2; Dr. M.K. Sharma, Scientist 'C'
Scientific/Technical Staff: Sri Dayanand, Technician 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:

- Development of low cost media for removal of fluoride from drinking water.
- Establishing the mechanism involved in removal of fluoride.
- Establishing the capacity of media for fluoride removal.

9. Statement of problem:

- Drinking (ground water) of Assam, Bihar, U.P, Punjab, Rajasthan, Gujarat etc. is contaminated with fluoride.
- Presence of fluoride in drinking water leads to fluorosis and is a main concern.

10. Approved Action Plan / Methodology

- Media will be synthesized from fly ash.
- Characterization of media will be done by SEM, TEM, XRD and wet analysis.
- Sorption study will be done in CSTR to find out sorption mechanism and kinetics of sorption.
- Column study will be done for application in field scale.
- The developed low cost material will be tested in the actual field condition.

11. Timeline:

Sr. No.	Major Activities	1st Year	2nd Year
1	Literature Survey		
2	Development of media		
3	Characterization and adsorption study		
4	Preparation of Final Report		

12. Objectives and achievement during last six months

Objectives	Achievements
Literature Survey	• Literature survey for research work on coal as well as bagasse fly ash and the available technologies for fluoride removal completed.
Development of media	• Bagasse Fly Ash collected from Iqbalpur Sugar Mill, Roorkee. • Two types of media synthesized. • Characterization of media under progress.

13. Recommendation / Suggestion

14. Analysis & Results

1. Literature survey for fly ash indicates that most of the research work has been carried out with coal fly ash. Very few researchers had utilized bagasses fly ash for contaminant removal. Moreover attempt to synthesis media / zeolite from bagasse fly is limited. Till date, media synthesized from fly ash has not been utilized for fluoride removal.
2. Two types of media synthesized from Bagasse Fly Ash and characterization of the same is under progress.

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

16. Deliverables **:** Paper & Report

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
Solution of identified problem	In progress
New product	In progress

21. Involvement of end users/beneficiaries: Local people

22. **Specific linkage with Institution and /or end users/beneficiaries**: Under identification with the problematic area authorities

23. **Shortcoming/Difficulties:** No

24. **Future Plan:**

- Synthesis of F selective media & characterization
- Lab trails followed by field trials

Study-3 (New study)

1. Title of the Study: **Water Quality Modeling of Hindon River**
2. Study Group:

Principal Investigator: Shri Omkar Singh, Scientist 'E2
Co-Investigators: Dr. V. K. Choubey, Scientist 'F'/ Head, EHD; Dr. M.K. Sharma, Scientist 'C'; Dr. Rajesh Singh, Scientist 'B'; Dr. A.R. Senthil Kumar, Scientist 'E1
Scientific/Technical Staff: Mrs. Babita Sharma, RA; Mrs. Beena Prasad, RA; Shri R.K. Goyal, Sr. Tech.; Shri Dayanad, Tech. Gr. II

3. **Type of Study**: Internal
4. **Nature of Study:** Monitoring and modeling of point source pollution
5. **Date of start:** 1.4.2012
6. **Scheduled date of completion:** 31.3.2015

7. **Duration of the Study:** 3 years
8. **Study Objectives:**

- To estimate rate of re-aeration and de-oxygenation coefficients in different stretches of the Hindon river
- To estimate downstream DO deficit in different stretches of using Streeter-Phelps oxygen sag equation
- To estimate reduction values of BOD loads of point sources (industrial/municipal wastewater) entering into the Hindon River in order to achieve a desirable level of DO for survival of aquatic fauna of the River

9. Statement of problem:

The amount of dissolved oxygen in water is one of the most commonly used indicators of a river's health. As DO drops below 4 or 5 rng/L, the forms of life that can survive begin to be reduced. In the extreme case, when anaerobic conditions exist, most higher forms of life are killed or driven off. Noxious conditions, including floating sludges, bubbling, odorous gases, and slimy fungal growths, then prevail. Therefore, the water quality modeling is necessary to estimate downstream DO deficit in different stretches using streeter-phelps oxygen sag equation. If DO deficit is greater as wells as river water attaining minimum DO level below limit (4.0 mg/l) for survival of aquatic life. Accordingly, it will be necessary to determine the possible reduction in wastewater BOD load through trial and error process to achieve a more desirable level.

In view of above, is proposed to estimate the DO deficit in various stretches of the river Hindon (a tributary of Yamuna River). 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.

10. **End Users / Beneficiaries of the study:** Policy makers, planners, Implementing Agencies/Industries and Government organizations.

11. **Whether study is a new study/extension of previous studies:** The Division has carried out a study on "Hydro-chemical studies of river Hindon' during 1998-99. In the present study, it is proposed to carry out water quality modeling in the different stretches of river Hindon which is regularly getting wastewater BOD loads of industries/municipalities.

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

The information of previous study will be used as base line data alongwith generation of new data through field and lab investigations.

13. Methodology

The water quality monitoring and samples analysis will be carried out using standards procedures (APHA, 1985/Jain & Bhatia, 1987). It is proposed to apply a simple model of the oxygen resources in a river having two key processes (i) the removal of oxygen by microorganisms during biodegradation, and (ii) the replenishment of oxygen through re-aeration at the surface of the river. In this connection rate of re-aeration in different stretches of the Hindon river would be determined using following equation (O' Connor and Dobbins, 1958):

$$Kr= (3.9u^{1/2})/(H^{3/2})$$

Where, u is average stream velocity (m/s) and H is average stream depth (m).

The de-oxygenation rate constant (Kd) 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 ^{o}C in accordance with Davis and Cornwell, 1985, Tabulated). The formula for k is given as below:

$$k =k_{20}\theta^{(T-20)}$$

Finally, the estimation of downstream DO deficit in different stretches will be modelled using Streeter-Phelps oxygen sag equation (Streeter and Phelps, 1925). The equation is given below:

$$D=(K_dL_0/K_r-K_d)(e^{-kdt}-e^{-krt})+D_0\ e^{-krt}$$

Where,
D = dissolved oxygen deficit (DO_s-DO)
DO_s= saturated value of dissolved oxygen

DO = actual dissolved oxygen at a given location in the river
K_d= the 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 pont and distance x downstream (x/u)
u= stream speed

14. Timeline:

Major Activities	1st year	2nd year	3rd year
Literature survey			
Data collection/Monitoring/Field & Lab Investigation (OKS,MKS,RS)			
Purchase of data/Software (QUAL2E/QUAL2K)			
Estimation of Reaeration &De-oxygenation coefficients (Reach wise) (OK,MKS)			
Development of Algorithm/Computer Program for DO Deficit (Streeter & Phelps Eq.) (ARSK, OKS)			
Analysis & Interpretation of data using computer program/model output (OKS,MKS,ARSK,RS)			
Preparation of Papers/ Report (OKS,MKS,ARSK,RS)			

15. Deliverables:

- Papers
- Report

16. Proposed measurable indicator

- Estimation of rate of re-aeration and de-oxygenation coefficients in different stretches of the Hindon river
- Estimation downstream DO deficit in different stretches
- Estimation of reduction values of BOD loads of point sources (industrial/municipal wastewater) entering into the Hindon River

17. Involvement of end users/beneficiaries: Local people/relevant Sectors

18. Specific linkage with Institution and /or other NGOs: None

19. Major items of equipment needed: WQ Lab facilities of NIH

Study-4

1. Title of the Study: **Impact of sewage effluent on drinking water sources of Shimla city and suggesting ameliorative measures**

2. Study Group:

Project Investigator Dr V K Choubey, Scientist 'F' & Head (EHD), NIH	
Co-Investigators	
Shri Omkar Singh, Scientist 'E2' Dr. M.K. Sharma, Scientist 'C' Dr. Rajesh Singh, Scientist 'B'	I & PHE Dept., Shimla (H.P.)

3. Type of Study: Sponsored

4. Date of start: 1.4.2009

5. Scheduled date of completion: 31.3.2012

6. Duration of the Study: 3 years

7. Study Objectives:

- Analysis of hydrological, water quality and basin characteristics of Shimla town.
- Assessment of water quality variable in drinking water sources and sewage effluent.
- Analysis of pollutant/source identification (location) of sewage effluent influx in drinking water.
- Impact assessment of sewage effluent in drinking water sources and suggesting possible remedial measures for its removal.
- Dissemination of knowledge and findings to field engineers and common people through preparation of manual, leaflets, booklets and by organizing workshops/training.

8. Statement of problem:

- Himachal Pradesh is one of the States which is included in the HP Phase II.
- Mass levels Jaundice have been reported due to influx of pollutants/bacteria in the drinking water in Shimla Town during 2007.
- After discussions with the officials of Himachal Pradesh, it is found that the assessment of impact of sewage effluent on drinking water sources of Shimla city is the real problem and needs to be assessed scientifically.

9. Approved action Plan:

- Analysis of hydro-meteorological and basin characteristics of Shimla City using ERDAS/ILWIS.
- Assessment of water quality parameters in drinking water sources and sewage effluent.

- Monitoring & evaluation of water quality parameters, essential for drinking water, from different drinking water sources and sewage effluent on quarterly basis using standard methods (APHA, 1995).
- Study of existing sewerage network efficacy using SEWERCAD in problem zone of Shimla, and source identification (location) of sewage effluent influx in drinking water.

10. Timeline:

Sr. No.	Major Activities	1st Year	2nd Year	3rd Year
1	Data collection			
2	Literature survey			
3	Staff appointment			
4	Purchase of equipment			
5	Field survey			
6	Generation of Maps, RS & GIS Applications			
7	Analysis and interpretation of WQ data			
8	Sewerage network, Pollution transport mechanism, & Impact assessment			
9	Preparation of Interim report			
10	Training / Workshop			
11	Preparation of Final Report			

11. Achievements

Objective	Achievement
Analysis of eco-hydrology, Hydro-meteorology and basin characteristics of study area	• Digital Elevation Model (DEM) of study area generated. • Watershed Characteristics are evaluated for problematic area of Shimla City lying under Yamuna basin.
Analysis of water quality parameters in drinking water sources and sewage effluent of study area	• Sampling and analysis for various physico chemical and bacteriological parameters (pH, EC, TDS, Ca, Mg, Na, K, HCO_3, Cl, SO_4, NO_3, PO_4, F, BOD, COD, total coliform, fecal coliform, etc.) of problematic area water samples completed. • Water quality data analyzed
Source Identification of sewerage effluent influx into drinking water	• Digitization/Preparation of Sewer Network map of Study Area (Sanjauli - Maliana Zone) completed. • Verification for efficacy of sewerage network of Sanjauli - Malyana Zone by Bentley SewerCAD software performed and interpretations completed.
Dissemination of knowledge	Three days training course on "Water quality and its management" was organized during June 28 – July 01, 2010 and Sept. 12-14, 2011 at HIPA, Shimla for field engineers of I&PH (HP).

12. Analysis and Results:

- Digital Elevation Model (DEM) of study area generated.
- Watershed Characteristics completed.
- Verification for efficacy of sewerage network of Sanjauli - Malyana Zone by Bentley SewerCAD software performed. Existing sewerage network is sufficient to cater the present load of municipal sewage.
- Out of 19 groundwater sampling locations spread across the study area 4 sites were found contaminated with fecal coliform.
- The groundwater of Shimla city was found to be of Ca-Mg-HCO_3 type having temporary hardness.
- Inlet water to water treatment plants (Dhalli & Ashwani Khud) supplying water to study area were found contaminated with organics (COD: 12-110 mg/L) as well as bacteria.
- Bore wells supplementing water to Ashwani Khud WTP are also contaminated with organics, fecal coliform and nitrate indicating contamination with sewage.
- Presence of organics in water leads to higher chlorine demand.

13. **Adopters of the results of the study:** I & PHE Dept., Shimla (H.P.)

14. **Deliverables:**
    - Training Programme - 22 participants were trained during the training course. Field visit to the participant were also organised and trained them for water sampling in water supply lines, water treatment plant and sewage treatment plant.
    - Reports

15. **Equipment Procured/under process**
16. **Laboratory facilities used**
    a. Water quality laboratory
17. **Data procured and generated**

    a. RS data from IRS-P6 LISS III
    b. Sewer network of Sanjauli-Malyana and Dhali zone
    c. SOI Toposheet of Shimla city
    d. Drainage map of Yamuna City
    e. DEM of Shimla city
18. **Study Benefits:**

Measurable indicators	**Achievements**
Identification of Contaminated sites	Achieved
Suggestions for remedial measures	Achieved

19. **Specific linkage with Institution/end user/ beneficiaries:**

    - I & PHE Dept., Shimla (H.P.)
20. **Shortcomings:** Nil
21. **Future Plan:** Submission of Final Report

GROUNDWATER HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr N C Ghosh	Scientist F & Head
2	Dr Anupama Sharma	Scientist E1
3	Sri Surjeet Singh	Scientist E1
4	Sri A K Dwivedi	Scientist C
5	Sri Rajan Vatsa	Scientist B
6	Sri Sumant Kumar	Scientist B
7	Ms Shashi Poonam Indwar	Scientist B
8	Sri Sanjay Mittal	SRA
9	Sri Ram Chandra	RA

WORK PROGRAMME FOR THE YEAR 2011-12

Reference Code	Study	Team	Duration	Funding Source
Internal Studies				
1. NIH/GWD/NIH /09-12/	Impact of Climate Change on Dynamic Groundwater Recharge in a Drought Prone Area	Surjeet Singh (PI) C.P. Kumar Anupma Sharma Rajan Vatsa	3 years (04/09– 03/12)	NIH
2. 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)	NIH
3. NIH/GWD/NIH /11-14	Groundwater Fluoride Contamination in different parts of India and study severity of Fluorosis in a Drought prone area	A.K. Dwivedi (PI) N.C. Ghosh, Anupma Sharma, Sumant Kumar, Sanjay Mittal, Ram Chandra	3 years (04/11– 03/14)	NIH
4. NIH/GWD/NIH /11-14	Management of Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)	Sumant Kumar (PI) Rajan Vatsa, N.C. Ghosh, C.P. Kumar, Surjeet Singh, Sanjay Mittal	3 years (04/11– 03/14)	NIH
Sponsored Projects				
5. 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, A.D. Gohil, C.K. Jain, Sudhir Kumar, D.S. Rathore, Surjeet Singh, Rajan Vatsa	3 years (10/09– 06/12)	PDS (HP-II)
6. 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: Bhishm Kumar, V. C. Goyal, C. K. Jain, Sudhir Kumar, B. Chakravorty, A. K. Lohani , Anupma Sharma, Surjeet Singh, Sumant Kumar	36 months (Oct, 2011-Sep,2014)	European Union
Consultancy Projects				
7.	Feasibility study of surface water and groundwater availability including identification of potential groundwater recharge sites in the CIFMR campus, Dhanbad		6 months w.e.f. August, 2011.	Engg. Projects (India) Ltd.

WORK PROGRAMME FOR THE YEAR 2012-2013

S. No.	Study	Team	Duration
Internal Studies			
1.	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**: In progress
2.	Groundwater Fluoride Contamination in different parts of India and study severity of Fluorosis in a Drought prone area	A.K. Dwivedi (PI), N.C. Ghosh, Anupma Sharma, Sumant Kumar, Sanjay Mittal, Ram Chandra	3 years (04/11 – 03/14) **Status**: In progress
3.	Hydrological Instrumentation and Data Monitoring Planning for Integrated Water Resources Management (IWRM) of the Bina River Pilot Basin	Surjeet Singh (PI), N.C. Ghosh, R.K. Jaiswal (RC-Sagar)	3 years (04/12 – 03/15) **New Study**
Sponsored Projects			
4.	Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat.	N. C. Ghosh (Coordinator), Anupma Sharma (PI), C P Kumar, A.D. Gohil, C.K. Jain, Sudhir Kumar, D.S. Rathore, Surjeet Singh, Rajan Vatsa, GWRDC Gandhinagar	3 years (10/09 – 06/12) **Status:** In progress
5.	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 & PI : N. C. Ghosh Other Team Members *(Tentative)* Bhishm Kumar, V. C. Goyal, C. K. Jain, Sudhir Kumar, B. Chakravorty, A. K. Lohani, Anupma Sharma, Surjeet Singh, Sumant Kumar	3 years (10/11 - 9/14) **Status:** In progress
6.	Management of Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR)	Sumant Kumar (PI),Rajan Vatsa N.C. Ghosh, C.P. Kumar, Surjeet Singh, Sanjay Mittal	3 years (04/11 – 03/14) **Status:** In progress
7.	Flow and Contaminant Transport Modeling of Riverbank Filtration	Shashi Poonam Indwar (PI), N.C. Ghosh, Anupma Sharma, Rajan Vatsa, Stefanie Fischer - Research Student (Germany) - six months, HTWD Germany, Uttarakhand Jal Sansthan (UJS), Haridwar & Dehradun	30 months (04/12 – 9/14) **New Study**

Consultancy Projects			
8.	Drainage Area mapping and hydrological studies in and around Gurha (W) Lignite Block in Kolayat tehsil of Bikaner District, Rajasthan	A.K. Dwivedi, N.C. Ghosh, Surjeet Singh, Rajan Vatsa, Sumant Kumar	9 months

1. PROJECT REFERENCE CODE: NIH/GWD/NIH/09-12

Title of the Study: **Impact of Climate Change on Dynamic Groundwater System in a Drought Prone Area**

Study Group:

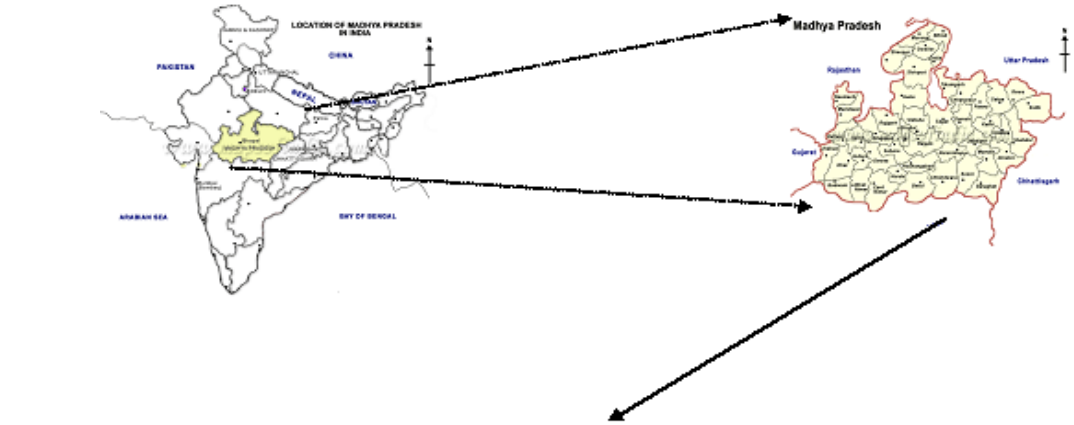
Dr. Surjeet Singh, Sc-E1, GWHD - **PI**
Mr. C. P. Kumar, Sc-F & Head, HID - **Co-PI**
Dr. Anupma Sharma, Sc-E1, GWHD
Mr. Rajan Vatsa, Sc-B, GWHD

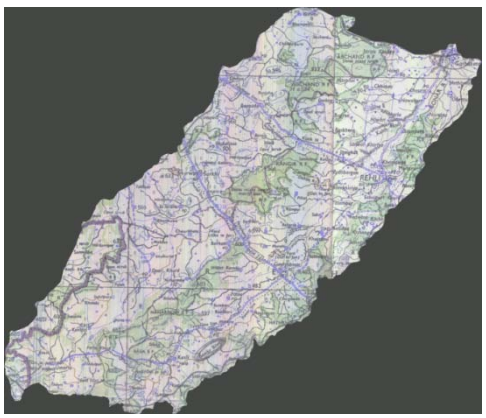
Funding: Internal

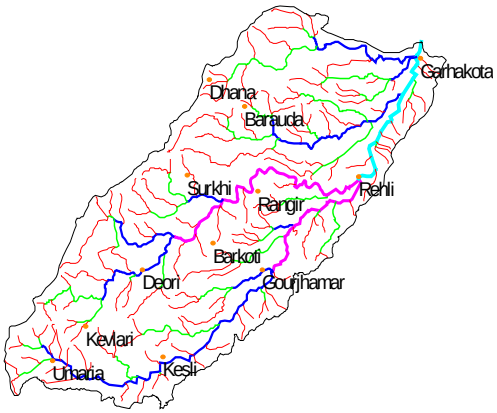
Date of Start: April 01, 2009

Scheduled Date of Completion: March, 2012

Location Map:







Statement of the Problem

Climate change is unequivocal. Due to this, there may be change in climatic variables, including rainfall intensity and distribution geographically which will result in change in groundwater recharge. Thus this study focuses impact assessment of climate change on groundwater system.

Approved action plan

- Basic data preparation using GIS
- Hydro-geological characterization of the study area
- Synthetic generation of daily values of precipitation, mean temperature, and solar radiation (using a weather generator)
- Estimation of groundwater recharge based on available precipitation and temperature records and anticipated changes to these parameters (using Visual HELP)
- Quantification of the spatially distributed recharge rates using the climate data and spatial soil survey data
- Simulation of groundwater flow using each recharge data set and evaluation of the changes in groundwater flow and levels in time.

Objectives & Achievements

To quantify the impacts of climate change on groundwater recharge in a part of Sonar basin, Madhya Pradesh.	The estimation of groundwater recharge at 12 locations in the basin has been completed. Quantification of change in groundwater recharge in response to climate change is also done.
To simulate the groundwater levels and investigate the temporal response of the aquifer system to historic and future climate periods.	The groundwater modeling for the simulation of groundwater levels in response to the estimated groundwater recharge is in progress and will be completed by 31st March, 2012.

Analysis and Results

1. Development of groundwater flow model.
2. Groundwater table simulations.

List of deliverables

1. Database development.
2. Reports – Part-I as Interim Report and Part-II as Final Report.
3. Papers: 01-published and 02-in process.

Lab facility used under the study

1. Soil and Water Laboratory, NIH.
2. Numerical Groundwater Modeling Unit (NGMU), NIH.

Data procured and generated

1. Meteorological data.
2. Geo-hydrological map.
3. GIS database.
4. Future weather data.
5. Soil database.
6. Groundwater model.

Study Benefits

The study will be beneficial to investigate the changes in groundwater recharge in response to the projected climate change and also to predict the groundwater table.

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

- End-users/beneficiaries: The study will provide inputs to "Climate change and "Groundwater domain".

Shortcomings/Difficulties, if any – Nil.

Future Plan

- Submission of Final Report by 30th April, 2012.

2. 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:

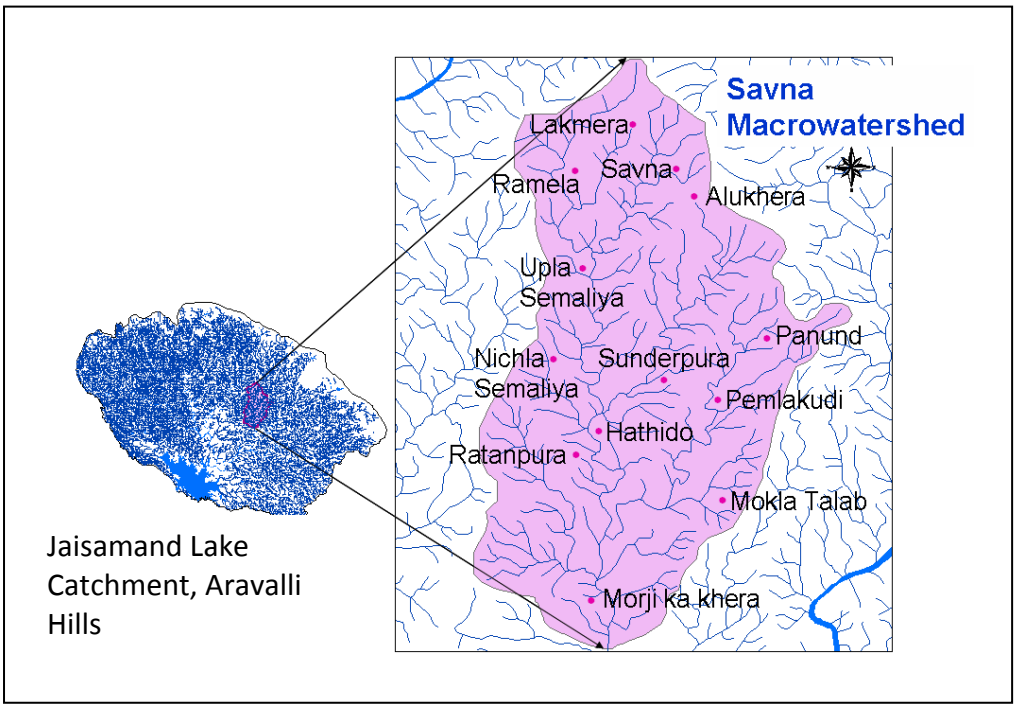
Dr. Anupma Sharma, Sc-E1, GWHD - **PI**
Mr. C. P. Kumar, Sc-F & Head, HID - **Co-PI**
Dr. N.C. Ghosh, Sc-F & Head, GWHD
Dr. Sudhir Kumar, Sc-F, HID
Mr. Rajan Vatsa, Sc-C, GWHD
Mr. Sanjay Mittal, SRA, GWHD

Type of study: 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: March 2012. Extension requested for six months.
Justification for seeking extension: Due to renovation work in Soil and Water Laboratory, the soil analysis, essential for the study, could not be completed. Additionally, some field tests and micro-level field data are also required.

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 analyse the hydrological impact of rainwater harvesting schemes on groundwater availability.

Objectives vis-à-vis Achievements:

Objectives	Achievements
Field visits	One visit undertaken since Oct. 2011.
Data monitoring	Quarterly water level monitoring of 314 wells. For wells located near four anicuts in Nichla Semaliya and Hathido villages in Savna watershed, monitoring on fortnightly basis in monsoon and on monthly basis in non-monsoon.
Field and lab experiments	Pump tests carried out at 2 sites. Collection of 54 soil samples (previously) for analysis in lab. Samples under analysis in laboratory. Soil moisture data monitored at varying depths (10-15 cm interval) at 15 days interval at five different anicut sites.
Mathematical modeling	Test runs on VS2DT to compute water flux through unsaturated zone.

Analysis and Results

1. Updating of database.
2. Mapping of weathered zone
3. Test runs on VS2DT to compute water flux through unsaturated zone.

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

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:

Measurable indicators	**Achievements**
Generation of database on GIS for Savna Macrowatershed	Database pertaining to hydrogeology, landuse and soil under progress
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:

Development of mathematical model (ongoing).

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

Title of the study: Groundwater Fluoride Contamination in different parts of India and study severity of Fluorosis in a Drought prone area

Study Team: Mr. Ashok Kumar Dwivedi, Sc-C, GWHD - **PI**
Dr. N.C Ghosh, Sc-F & Head, GWHD
Dr Anupma Sharma, Sc-E1, GWHD
Mr Sumant Kumar, Sc-B, GWHD
Mr Sanjay Mittal, SRA, GWHD

Type of study : Internal

Date of Start : 1st April, 2011

Scheduled Date of Completion : 31st March, 2013

Location Map Identification of the study area will follow after position document on Fluoride is brought out.

Objectives: i) Preparation of a position document on Ground Water Fluoride Contamination in India, and
ii) To study variability and severity of fluorosis in a selected region (drought prone area);

Note : Members of 34th WG suggested to prepare first a status report on fluoride contamination in India and include relation of Boron with Fluoride in the report. Second part of the study was suggested to be dropped for the time being.

Statement of the problem, End users/beneficiaries of the study:
Excess fluoride in groundwater-based drinking water supply is a growing concern in more than 25 countries of the world. The problem of fluoride contamination in India is growing fast. Recent studies conducted by UNICEF, World Bank, CGWB, Central Pollution Control Board and State Pollution Control Boards and many academic and research institutions indicate that more than 17 states of the country are under the problem of fluoride contamination.
A Status Report is envisaged to be prepared.

Approved action plan

Literature Review, Field investigation & data collection, and writing of Status Report

A workshop on fluoride and fluorosis issue was proposed to be conducted in the month of January, 2012, but the draft report is not ready, the same would follow only after completion of the report.

Objectives & Achievements

To prepare a status report on Groundwater Fluoride Contamination in different parts of India	Literature review from publications till 2011 is complete. Writing of the report is in progress. A draft report which was expected by December 2011 will be ready by April 30, 2012.

	Workshop on fluoride may be organized sometimes in June, 2012 after the report is ready.

Analysis and Results: Under review

L**ist of deliverables:** Report and papers etc.

4. 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:

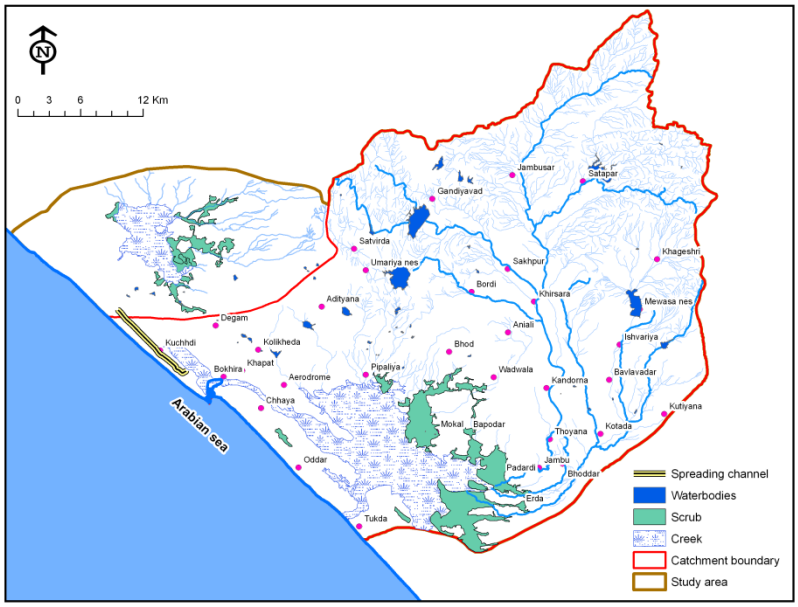
- Study Coordinator : Dr N C Ghosh, NIH
- PI : Dr. Anupma Sharma, NIH
- Co-PI : Mr. C P Kumar, NIH
  Mr. A D Gohil, GWRDC, Gandhinagar
- Co-investigators : NIH - Dr. C.K. Jain; Dr. Sudhir Kumar;
  Mr. D.S. Rathore; Dr. Surjeet Singh; Mr Rajan Vatsa
  GWRDC - Research Officer, Gandhinagar; Geologist, 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: June 31, 2012 **Extended date for HP-II**: March 31, 2012

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	Five since April 2011.
Data collection	Collection of data about landuse, pump tests, groundwater draft, spreading channel, irrigation schemes, relevant reports and maps, meteorological data
Data monitoring	Water level and water quality data monitoring on quarterly basis in 40 wells and on monthly basis in 26 wells, including creeks and reservoir schemes near coast.
Field experiments and Laboratory investigations	- Soil samples collected from field: 20 disturbed - Soil samples analyzed in laboratory for soil moisture characteristics

	- Installation of data loggers and measurement of groundwater level, temperature and salinity using data loggers at three sites - Pump tests conducted : 11 sites - Measurement of salinity profiles through TLC meter - Geophysical Surveys (VES) at 17 locations - Experiments using seepage meter
Database preparation	DEM of Minsar basin developed, Fence diagram, Land use, Pump test data, Water balance.
Data analysis	Analysis of satellite data, pump tests, landuse, lithologs, water table and water quality data. Analysis of soil samples and data 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. Socio-economic survey in 16 villages

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. Fabrication of seepage meter

Lab facilities used during the study:

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

Data procured and/or generated during the study:

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

Study Benefits/Impact:

Measurable indicators	**Achievements**
Generation of database on GIS for Minsar River Basin	Database pertaining to hydrogeology, landuse and soil
Hydrological water balance	Computation of water balance components
Technology transfer	Demonstration about usage of equipment (aquameter, CTD diver, TLC meter) to

	GWRDC 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
3. Organization of training course on 'Groundwater Management in Coastal Aquifers' for Officers of Gujarat State during Dec. 3-7, 2012 at Rajkot, Gujarat.

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

i. EU Sponsored multi-stakeholders Collaborative R & D Project entitled:

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

ii. Total Project cost: Appox. 3.5 million Euros.

iii. NIH's share : 2,42,044 Euros

iv. Duration: 36 months (October, 2011 – September, 2014).

v. **NIH's Study Team**

Project Director : R. D. Singh, Director, NIH
Project Co-coordinator & P. I. : N. C. Ghosh

Study Team:
V. C. Goyal; C. K. Jain; Sudhir Kumar; B. Chakravorty; A. K. Lohani ; Anupma Sharma; Surjeet Singh; Sumant Kumar, and Mrs. Shashi Indowar.

vi. List of Work Packages

LIST OF WORK PACKAGES (WP)

WP Number [53]	WP Title	Type of activity [54]	Lead beneficiary number [55]
WP 1	Bank filtration in urban areas under varying pollutant loads and flood situations	RTD	16
WP 2	Managed aquifer recharge and soil aquifer treatment	RTD	13
WP 3	Constructed wetlands and other natural treatment systems for wastewater treatment and reuse	RTD	11
WP 4	Post-treatment of water from natural treatment systems for different applications	RTD	17
WP 5	Modeling and system design	RTD	14
WP 6	Integrated sustainability assessment	RTD	15
WP 7	Training and dissemination	RTD	3
WP 8	Management	RTD	1

vii. NIH's involvement

- In Work Packages (WP) - WP 1, WP2 , WP 5 and WP7.
- In which, NIH is the Lead agency in WP7.

viii. Targeted Areas for R & D works

For WP 1 : Hardwar, Srinagar, Nainital, and NCT Delhi.
For WP 2 : Municipal area Raipur, Maheshwaram (Warangal, Andhra Pradesh).
For WP 5 : Based on the baseline data to be collected from WP1, & WP2.

ix. Progress made so far:

NIH had organized the Kickoff meeting during 3-4 November, 2011 at India Habitat Centre, New Delhi. In which, all 20 participating organizations attended, discussed, deliberated and finalized the work programme for the coming one year (2011-12).

As follow up tasks, NIH has taken initiative to carry out R & D programs for the WP1 & WP2, and field visits and data collection efforts are in progress.

As the leader of the WP7(Training & Dissemination): A training course entitled "Bank Filtration for Sustainable Drinking Water Supply in India" is being organized as add on to the "India Water Week-2012" on 13th April, 2012 at New Delhi, in addition to exhibiting the "Saph Pani" project in the IWW as a Platinum Sponsor.

The first review meeting of the project to take stock of the progress and finalize the activities for future is scheduled to be held at Basel, Switzerland during 9-11 May

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

Title of the Study: Management of Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR) [Under the framework of 'SAPH PANI' Project Work Package – II]

Study Team

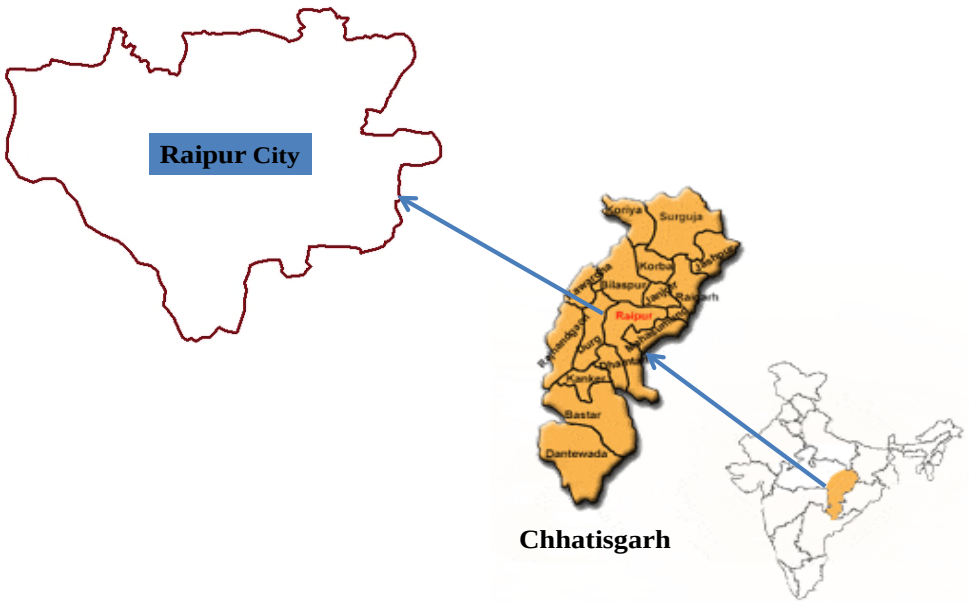
Mr. Sumant Kumar, Sc-B, GWHD - **PI**
Mr. Rajan Vatsa, Sc-B, GWHD - **Co-PI**
Dr. N.C Ghosh, Sc-F & Head, GWHD
Mr. C. P Kumar, Sc-F & Head, HID
Dr. Surjeet Singh, Sc-E1, GWHD
Mr. Sanjay Mittal, SRA, GWHD

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



Objectives

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

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

Raipur city is situated in the plains of the Mahanadi River basin in the state of Chhattisgarh. Presently the population of the city is nearly 1,200,000 and water supply requirement of the city is mainly met from the Kharun River- a tributary of the Mahanadi River. The aquifer underneath the Raipur city is consisted mainly of deeply weathered baseline rocks comprised of lime stone, sandstones and shales. Approximately 65% of the city's drinking water supply is met from Kharun River and the rest is supplied from Groundwater resources by number of hand pumps and tube wells. Raipur city has 154 small and large water bodies. These water bodies are natural and manmade locally called "talab". These talabs are connected by storm water channels and hence specific catchment area. Out of 154 talabs, 85 talabs are in existing presently, remaining talabs have lost their entity because of the development activities. Most of the talabs out of 85 face deteriorating water quality due to disposal of municipal wastes both solid and liquid.

In one hand, the area has the deteriorating surface water quality in the "talab", on the other hand, groundwater levels are depleting due to excessive withdrawal, these indicate a problem of groundwater scarcity and deteriorating surface water quality, triggering to a problem of supply management issues. Managed Aquifer Recharge (MAR) and Aquifer Storage Recovery (ASR) which have been used in many developed countries to resolve supply-demand management of groundwater resources, could be used in this case also to address the problem. MAR can be employed to enhance recharge rate from the talab to the aquifer through aquifer storage treatment, while ASR can be used to recover aquifer aquifer storage for groundwater withdrawal.

The study is thus aimed at to analyze and develop MAR-ASR based model considering one of the talab catchments as a pilot.

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	Literature review has been completed. A field visit to identify and understand the site has been carried out along with officials of RMC. Data collection is in progress.
To model & analyze aquifer response due to the recharge from the identified potential recharge site	Consultations with NGRI & RMC are in progress. The modeling task will be taken up after obtaining adequate data.
To manage the augmented GW resources for subsequent potential uses	Will be taken up after completion of second objective.

Analysis and Results

A compilation report based on the review of literature on status of MAR in India is underway and likely to be completed by 15th April 2012. Basic information of hydrological data and hydro geological data of the catchment area have been collected.

List of deliverables
Reports and papers etc.

Other Technical Work and Services Carried out by the Groundwater Hydrology Division during October 2011 – March 2012:

1. Organized the First 'Saph Pani' Project Workshop on "*Enhancement of Natural Water Systems and Treatment Methods for Safe and Sustainable Water Supply in India"* during Nov. 3-4, 2011 at India Habitat Centre, New Delhi.

2. A consultancy project entitled "Feasibility study of surface water and groundwater availability including identification of potential groundwater recharge sites in the CIFMR campus, Dhanbad" of six months duration with project cost of Rs. 15.07 lakhs from the Engineering Projects (India) Ltd. , A Govt. of India Enterprise, has been completed.

3. A consultancy project entitled "Drainage Area mapping and hydrological studies in and around Gurha (W) Lignite Block in Kolayat tehsil of Bikaner District, Rajasthan" of nine months duration with project cost of Rs. 12.5 lakhs from Rajasthan State Mines & Minerals Ltd, Govt. of Rajasthan has been awarded .

4. The scientists of the Division have submitted/published a number of research papers in various journals/conferences/symposia during the period and also delivered lectures in various training courses.

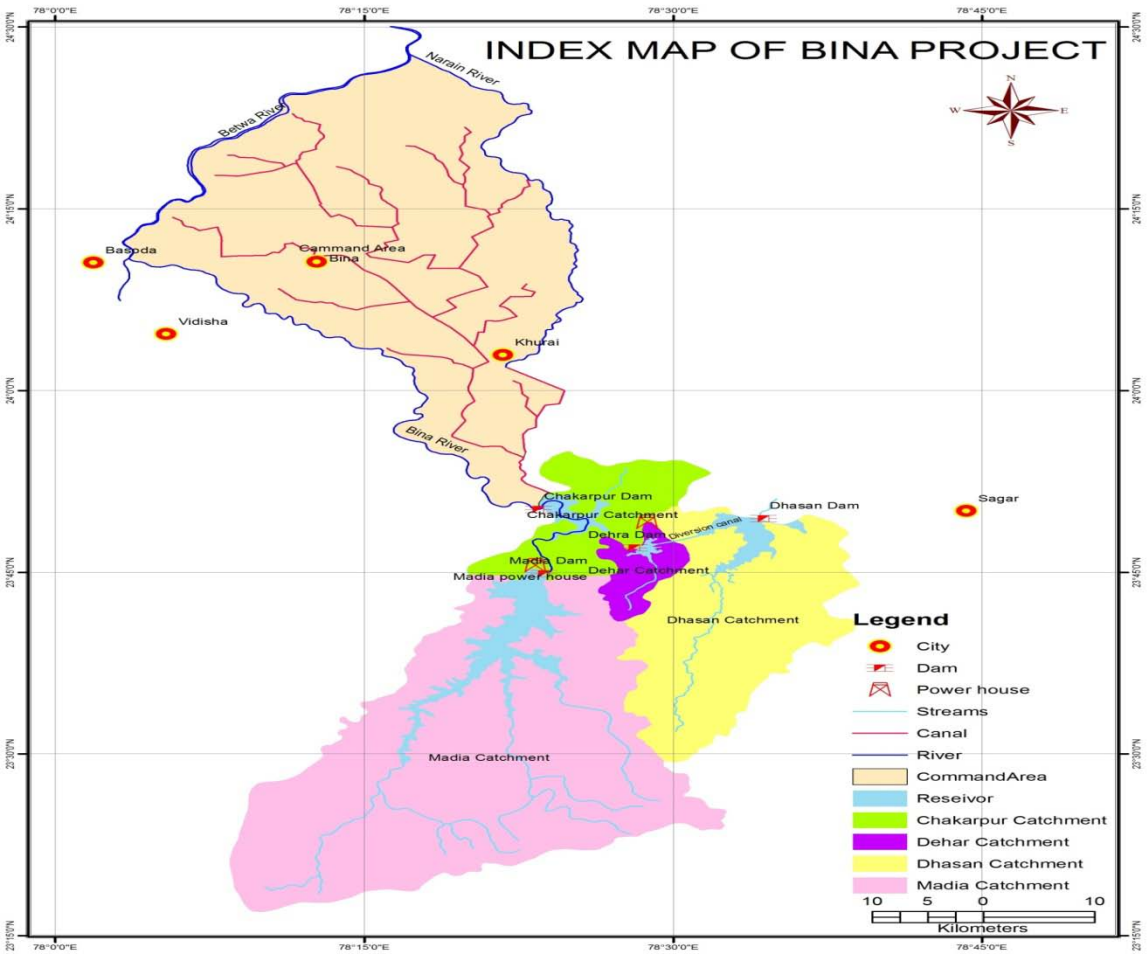
5. Two scientists; Dr. Surjeet Singh, Sc.-E1 and Dr. Anupma Sharma, Sc.-E1 are involved in Development of DSS for Integrated Water Resources Development and Management (under HP-II) for the states of Chhattisgarh and Gujarat along with DHI (Denmark & India) and State Department officers.

Details of new studies for the year 2012-13

(the proposed work programme for the year 2012-13 includes continuing studies from previous year)

1. NEW STUDY

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, GWHD - **PI** Dr. N.C. Ghosh, Sc-F & Head, GWHD - **Co-PI** Mr. R.K. Jaiswal, Sc-C (RC-Sagar)
Date of Start	:	1st April, 2012
Scheduled Date of Completion:		31st March, 2013
Duration of the Study	:	One year
Type of Study	:	Internal
Nature of Study	:	Planning
Location Map	:	Bina basin



Bina river is a major tributary of River Betwa in Bundelkhand region of Madhya Pradesh, which originates from Begumganj block of Raisen district. Presently, domestic

water supplies to Rahatgarh, Khurai and Bina town; railways requirement at Bina Railway junction and industrial supplies for Bina Refinery and proposed JP power project are met from this river besides irrigation water requirements. “Bina Complex- Irrigation and Multipurpose Project” has been proposed by the Water Resources Department, Govt. of Madhya Pradesh which is an ambitious project of the region for irrigation, power generation, industrial and domestic water supply, etc. Under this project, four dams are proposed- two on river Bina and one each on Dehra and Dhasan rivers. The Madia dam and Chakarpur dam-cum-pickup weir are proposed on river Bina, Dhasan diversion on river Dhasan and Dehra dam on river Dehra, a tributary of Bina river.

The catchment area of Madia dam is 1139 sq. km. To expliote the power potential of Madia dam, underground power house is proposed on this location to generate 22 MW power. The tail water releases from Madia power house will be stored in another dam namely Chakarpur dam. The Chakarpur dam is proposed on river Bina which is 55 km from Sagar and catchment area is 187.00 sq. km. In the project, Dhasan diversion dam has been proposed to divert water from Dhasan river to the Bina river. The catchment area of Dhasan diversion dam is 464.50 sq. m. The project consists of Dehra dam on river Dehra which is a tributary of river Bina is 36 km away from Sagar with catchment area of 62.50 sq. km. In the project, water stored in Dahasn dam will be diverted to Dehra dam through a feeder canal. To exploit the hydro-electric potential of Dhasan and Dehra, water stored in Dehra dam will be used for generation of 10 MW power through the power house.

Under the XIIth Five Year (2012-17) Plan of NIH, the Regional Centre, Sagar has proposed to carry out a Pilot Study of the basin by developing appropriate hydrological instrumentation and their continuous monitoring to develop guidelines for IWRM. It is in that context, a comprehensive analysis based on the available information shall be carried out to plan meteorological/hydrological/hydro-geological instrumentation network and data collection system and procedure to enable to develop an IWRM strategy of the basin.

Study Objectives:

1. To analyze and schematize of the existing and proposed schemes of the water usages pattern in the basin under the GIS framework.
2. To identify and plan the meteorological/hydrological/hydro-geological data monitoring networks, and devising instrumentation requirement for developing guidelines for the IWRM.

Statement of the Problem:

In the XIIth Five Year Plan, NIH and its Regional Centres have to work on pilot basins. In this regard, 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. The outcome of this study will

emerge as a guideline for planning hydrological instrumentation and data collection procedure to achieve the objectives of IWRM.

Brief Methodology

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

Milestones and Expected Output / Outcome

The results of the study will provide guidelines for planning of IWRM of the basin in the form of optimum instrumentation, increase in water resources, supply-demand analysis and groundwater sustainability.

2. NEW STUDY

Title of the Study: Flow and Contaminant Transport Modeling of Riverbank Filtration.
[Under the framework of 'SAPH PANI' Project Work Package - I – Bank Filtration in Urban Areas under varying Pollutants Loads and Flood situation]

Study Team:

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

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

Nature of study: Technology or technique development

Study objectives:

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

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

Statement of the problem: Uttarakhand Jal Sansthan, Haridwar has installed 23 nos. of Infiltration wells along the bank of the river Ganga. These wells are operated to supply drinking water to the nearby areas in the Haridwar City even without post treatment. These wells are located at varying distances (5m-25m) from the river bank and have been constructed at varying depths below ground surface. It is considered that due to bank filtrations & mixing of nearby groundwater, those wells are producing good quality of water, to the extent of permissible limit, and removing the pathogenic loads satisfactorily.

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

End users/beneficiaries of the study: The study would help in understanding the bank filtration processes and would also help promoting the techniques in other areas.

Baseline data:
Data requirements for setting up a bank filtration model are:

- Model domain fixation based on the locations of the wells & topography.
- Details of the infiltration well locations.
- River cross-section, river hydraulic data and well hydraulic data.
- Pumping schedule of the wells.

- Aquifer properties (hydraulic conductivity storativity, riverbed material properties etc)
- Distance of the Infiltration wells from the Riverbank.
- Quality of source water-river and well.

Methodology

(i) The existing riverbank filtration sites (23 Infiltration Wells) maintained by Uttarakhand Jal Sansthan, Dehradun along the bank of the river Ganga will be considered for modeling.
(ii) Water Quality of the river and the filtrate water are being monitored by the Uttarakhand Jal Sansthan will be considered for modeling.
(iii) Aquifer and hydraulic connectivity between the river and the aquifer will be characterized based on the litholog/borelog data and flownet data.
(iv) The flow nets for each bank filtrate well will be analyzed by developing analytical model.
(v) All the wells being located in the nearby neighborhoods of the Ganga River, a regional model considering all wells under the single GIS framework will be developed.

1. A GIS-based three-dimensional finite difference groundwater flow model using MODFLOW will be developed to simulate ground-water flow, flow path, travel time and to estimate the quantity of river water entering in the well.
2. To analyze the contaminant transport, an ADE model (advection dispersion equations) coupled with suitable kinetic processes of MT3D linked to MODFLOW.

Action plan and timeline: 2 years 6 months

- 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)
- Final Report preparation (3 months)

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

Proposed measurable indicators for assessment of study's achievements:

- To improve the understanding of the riverbank filtration processes and development of method and technical details.
- Scientific publications.
- Training Workshop.

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 Suhas Khobragade	Scientist E1
4	Dr S P Rai	Scientist E1
5	Dr M S Rao	Scientist E1
6	Sri S K Varma	Scientist C
7	Sri P K Garg	Scientist B
8	Sri Rajeev Gupta	SRA
9	Sri U K Singh	SRA
10	Sri V K Agarwal	SRA
11	Sri Jameel Ahmed	SRA
12	Sri Vishal Gupta	RA

WORK PROGRAMME FOR THE YEAR 2011-12

Reference Code	Study	Team	Duration/ Status
Internal Studies			
NIH/HID/INT/09-12	SW and GW Interaction at Selected Locations Along River Yamuna in NCT, Delhi: Phase-II	Sudhir Kumar (PI) M. S. Rao P. K. Garg	3 years *(4/09 –3/12)*
NIH/HID/INT/10-13	Study of Variability of Snow and Glacier Contribution in Melt Water of Gangotri Glacier at Goumukh using Isotopic Techniques	S.P. Rai (PI) Manohar Arora, Bhishm Kumar, Rakesh Kumar and Naresh Kumar	3 years *(4/10–3/13)*
NIH/HID/INT/10-12	Identification of Recharge Zones of Some Selected Springs of Uttarakhand Using Isotopes	S. D. Khobragade (PI) Bhishm Kumar, Sudhir Kumar, S. P. Rai, Pankaj Garg + Uttarakhand Jal Sansthan	*2 years (04/10-03/12)*
NIH/HID/INT/11-13/1	Assessment of Radon Concentration & Identification of Paleo Groundwater in Punjab State	S K Verma (PI), Sudhir Kumar M S Rao, Bhishm Kumar	*2 years (04/11-03/13)*
NIH/HID/INT/11-13/2	Hydrological Assessment for Artificial Recharge and Water Management in Ghar Area, Saharanpur District, U.P.	P.K.Garg (PI), Sudhir Kumar, Tanveer Ahmad, Rajesh Agarwal, V C Goyal, Bhishm kumar	*2 years (04/11-03/13)*
Sponsored Projects			
NIH/HID/DST/07-12	National programme on isotope fingerprinting of waters of India (IWIN)- **DST**	M.S. Rao (PI), B. Kumar, Sudhir Kumar, S.P. Rai, S.K. Verma, Pankaj Garg + other 13 organizations	5 years *(07/07–06/12)*
NIH/HID/FRI/08-13	Impact Assessment of Landuse on the Hydrologic Regime in the selected Micro-watersheds in Lesser Himalayas, Uttarakahand- **FRI**	S.P. Rai (PI) Bhishm Kumar J.V. Tyagi	5 years *(04/08–03/13)*
NIH/HID/GBPIHED/10-13	Development of Spring Sanctuaries in an Urban and Rural Watershed in District Pauri Garhwal, Uttarakhand- **GBPIHED**	Dr. S.P. Rai (PI), Bhishm Kumar, Sudhir Kumar, Suhas Khobragade, Pankaj Garg	3 years *(04/10-03/13)*
NIH/HID/HP-II/09-12	Groundwater Dynamics of Bist-Doab Area, Punjab Using Isotopes- **HP-II**	M.S. Rao (PI), Bhishm Kumar, Sudhir Kumar, S.K. Verma, PankajGarg +CGWB Officials	3 years *(07/09-6/12)*
NIH/HID/HP-II/09-12	Groundwater Management in Over- Exploited Blocks of Chitradurga and Tumkur Districts of Karnataka- **HP-II**	Sudhir Kumar (PI), J.V. Tyagi, Vijay Kumar, B.K. Purandara, S.P. Rai, M.S. Rao + DMG, Karnataka	3 years *(07/09-6/12)*
NIH/HID/CONS/1	Integrated Hydrological	S. D. Khobragade (PI)	2 years

Reference Code	Study	Team	Duration/ Status
1-13	Investigations of Sukhna Lake, Chandigarh for its Conservation and Management- **Forest dept. Chandigarh**	S. P. Rai Bhishm Kumar Vipin Agrawal, SRA	(07/11-6/13) **New study**
Consultancy Projects			
NIH/HID/DJB/10-11	Assessment of Groundwater Resources & Development Potential of Yamuna Flood Plain, NCT, Delhi- **Delhi Jal Board**	Sudhir Kumar (PI) Vijay Kumar + IITD,DU,CGWB, IARI, CWC,DJB	1 year *(02/10-01/11)*
NIH/HID/RSMML/JKT/10-12	Hydrogeological studies of Jhamarkotra Mines, Udaipur, Rajasthan- **RSMML, Udaipur**	Sudhir Kumar (PI), M.S.Rao, S.K. Verma, Pankaj Garg	1.5 years *(07/10-12/11)*

WORK PROGRAMME FOR THE YEAR 2012-2013

S. N.	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 Bhishm 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	Pankaj Garg (PI) Sudhir Kumar V.C. Goyal M. S. Rao C. P. Kumar Tanveer Ahmad Rajesh Agarwal	***2 years*** *(04/11-03/13)* ***Continuing Study***
4	Assessment of Sensitivity Open Water Evaporation Increase in temperature Different climatic regions of India	S. D. Khobragade (PI) C. P. Kumar Manohar Arora A. R. Senthil Kumar	***2 years*** *(04/12-03/14)* ***New study***
Sponsored Projects			
5	National Program on Isotope Fingerprinting of Waters of India (IWIN)	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. P. Rai S. K. Verma Pankaj Garg	5 years *(07/07–06/12)* *(To be extended upto Aug, 2013)* ***Continuing Study***
6	Groundwater Dynamics of Bist-Doab Area, Punjab Using Isotopes	M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. K. Verma PankajGarg CGWB Officials	3 years *(07/09-6/12)* ***Continuing Study***
7	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	3 years *(07/09-6/12)* ***Continuing study***

S. N.	Study	Team	Duration / Status
		Prof. C. Rangaraj	
8	Impact Assessment of Landuse on the Hydrologic Regime in the selected Micro-watersheds in Lesser Himalayas, Uttarakahand	S. P. Rai (PI) Bhishm Kumar J. V. Tyagi M. P. Singh, FRI Rajeev Tiwari, IGNA Vishal Gupta Jamil Ahmad V. K. Agarwal	5 years *(4/08– 3/13)* ***Continuing Study***
9	Development of Spring Sanctuaries in an Urban and a Rural Watershed in District Pauri Garhwal, Uttarakhand	S. P. Rai (PI) Bhishm Kumar Sudhir Kumar S. D. Khobragade Pankaj Garg Jamil Ahmad Vishal Gupta	3 years *(04/10-03/13)* ***Continuing Study***
Consultancy Projects			
10	Hydro-geological Studies of Jhamarkotra Mines, Udaipur, Rajasthan	Sudhir Kumar, (PI) S K Verma, Pankaj Garg,	1 year (07/10-06/11) Extended upto Dec, 2012 **Continuing Study**
11	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 Vipin Agrarwal	3 years *(07/11-06/13)* **Continuing Study**

WORK PROGRAM FOR THE YEAR 2011-12

1. REFERENCE NUMBER: NIH/HID/DST/07-12

1	**Title of the study**	:	NATIONAL PROGRAM ON ISOTOPE FINGERPRINTING OF WATERS OF INDIA (IWIN)
2	**Name of PI, Co-PI and their affiliations**	:	Dr. M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. P. Rai S. K. Verma Pankaj Garg
3	**Type of study**	:	Sponsored (Funded by DST vide IR/54/ESF/05-2004 dated July17, 2007)
4	**Date of start, Scheduled date of completion**	:	September, 2007 August, 2012 (extension for 1 year is recommended by PRC and now it will be August, 2013)
5	**Location map**	:	Samples are collected by NIH from 7 sites (Roorkee, Sagar, Jammu, Kakinada, Tezpur, Kanpur and Manali) and member organizations collect samples from 85 sites all over India.

NIH-IWIN SAMPLING LOCATIONS MAP

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

6	**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.

7 **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

8 **Approved action plan** **:**

Year	March, 2012 to August, 2013 (Appendix I)	Remark
March 2012 - August 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)**: Item 2 as at Roorkee (GLV by cond.) **Data Collection**: Hydro-meteorological at Roorkee, Sagar, Jammu, Kakinada, Tezpur, Kanpur and Manali. **Analysis**: Analysis of water samples (NIH, Sagar, Jammu, Kakinada, Tezpur, Kanpur & Manali) and samples provided by participating organizations for δD, $\delta^{18}O$ and ^{3}H. **Data interpretation** **Report writing**	Report preparation as per the Appendix I

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

10 **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	Qualitatively resolved the regional/local water vapour components in the local atmosphere and identified through correlation of isotopic data with wind trajectory. Results have been presented in an International Conference (OCHAMP-12) at IITM, Pune.
	In Progress	To understand the dynamics of the regional moisture, isotopic data of GLV from network of stations along different wind paths are being collected. The correlation will be analyzed to identify signal transfer and phase lag for its application to study the monsoon system.
Isotopic database development	In progress	Isotopic database has been developed for approximately 21000 samples =7200 (NIH) + 13800 (PRL)

11 **Recommendations/suggestion in previous meeting of Working Group :**

- **Suggestion:** Mr. R. D. Singh suggested to develop isotope based empirical relations for forecasting of monsoon.
  Action Taken: Towards this, a network of stations in Gangetic plains from Kanpur to Manali (Kanpur, Roorkee and Manali) is developed. One station is being planned at Patna RC of NIH to track monsoon vapours in Gangetic plains. After getting data for at least one year, the suggested empirical relation can be developed. The results of the samples collected from Roorkee, Kanpur and Manali for the post-monsoon season will be presented in the working group.
- **Suggestion:** Dr. V. V. Rao and Dr. Kakade emphasized on establishing few more stations for understanding the regional dynamics of vapour and to correlate with all possible meteorological parameters.
  Action Taken: Due to limited time remained for the project completion, only one station will be attempted to establish in the Indo-Gangetic plain. Work towards collection of other meteorological parameters is in progress.
- **Suggestion:** Mr. Ritesh Arya suggested need of such studies in advance warning of events such as cloud bursts or similar events in high altitudes of Himalayas. He advised to develop a few stations for isotope analysis in high altitude cold deserts or alpine areas like at Leh, where IMD

observatory is available.

Action Taken: We have already established a high altitude station at Manali, HP and we are getting the data analyzed for the samples collected there. Due to limited time slot of the instrument available for sample analysis, minimum number of stations have been kept as per the requirement of the project. More stations may be added in IWIN Phase 2.

- **Suggestion:** Dr. S.K. Singh, NIH suggested to identify the time required for vapours to travel between two NIH-IWIN stations and to use it in predicting the onset and withdrawl of monsoon.

  Action Taken: The work in this regard can be done on receiving the data from Patna to Manali at least for one complete year.

- **Suggestion:** Dr. B. P. Singh suggested to estimate onset and withdrawal dates of monsoon using δ^{18} O and δ D independently and to inter-compare these dates to confirm the validity of technique.

  Action Taken: The onset and withdrawal dates are same when δ^{18} O and δ D data is used independently.

12 **Analysis and Results :**

- Collected 857 samples since November, 2011 and out of which 252 samples have been measured.

Results

Isotopic comparison of GLV:

Roorkee & Hyderabad

- The time variation of atmospheric vapour (δD and δ^{18}O) from January, 2008 to December, 2010 observed at the stations Roorkee (NIH) and Hyderabad (NGRI) shows similar annual cyclic variation of isotopic composition of air moisture at both the stations with their troughs and crests

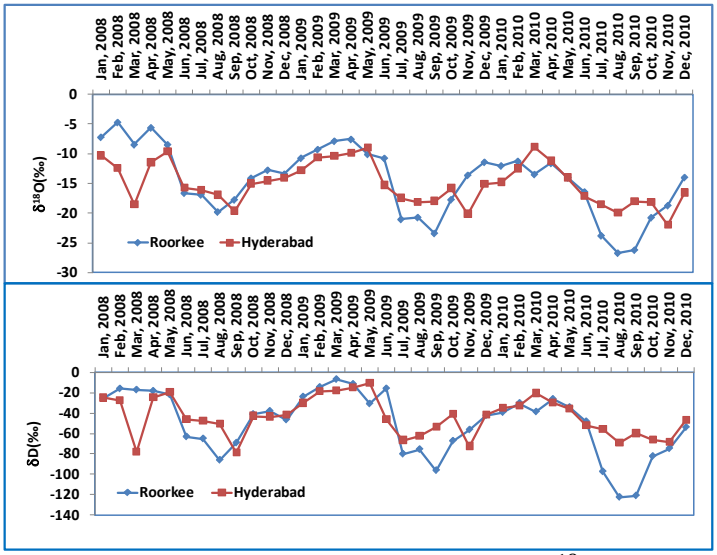


Fig. 2. Variation in isotopic composition (δ^{18}O and δD) at Roorkee and Hyderabad (2008-10)

appearing during July to September (which is monsoon period) and February to April, respectively. The overall variation in isotopic composition during an annual cycle is about 15‰ in $\delta^{18}O$ and 60‰ in δD at Roorkee and approximately 10‰ in $\delta^{18}O$ and 60‰ in δD at Hyderabad. It is unusual to get similar periodic isotopic pattern at both these stations which are geo-climatically well separated from each other.

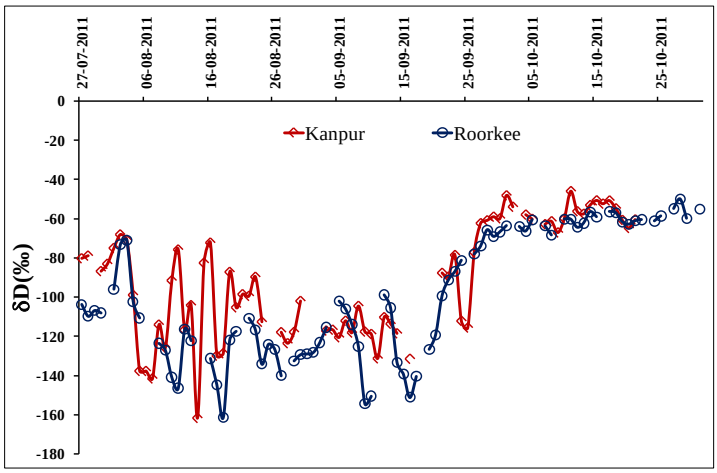


Fig.3. Variation in isotopic composition (δD) at Roorkee and Kanpur

Roorkee, Kanpur & Manali

- A good correlation is also observed between the isotopic composition of air moisture at Roorkee, Kanpur and Manali.

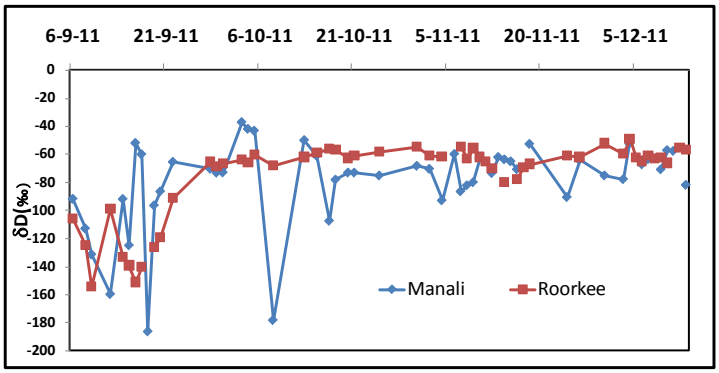


Fig. 4.Variation in isotopic composition (δD) at Roorkee and Manali

- Application to forecasting of onset and withdrawal of monsoon: A comparison of dates for onset and withdrawal given by IMD and dates as estimated from isotopic composition of GLV at Roorkee, it is inferred that the technique can be developed in forecasting of monsoon. Further confirmation of this may require analysis of data from other stations of the network.

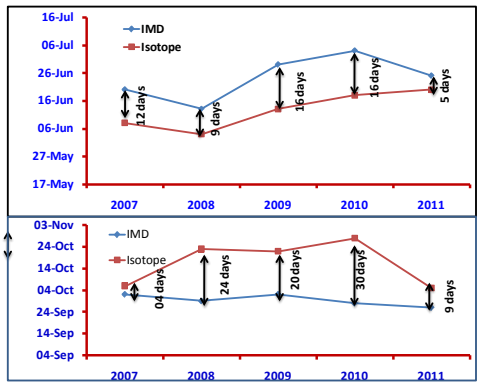


Fig. 5.Difference in monsoon onset and withdrawal dates (IMD and stable isotopes)

13 **Adopters of the results of the study and their feedback** : The IWIN project is a national level program 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 &

globally.

14	**List of deliverables** (e.g. equipment, papers, reports, software, manuals, brochures, flyers, training programs, users interaction workshops)	**:**	**Publications** ➢ Gopal Krishan, M. S. Rao and Bhishm Kumar. 2011. Instrumentation for measurements for isotopic composition of air moisture. *Journal of Instruments Society of India*. 41:217-220. ➢ Gopal Krishan, M. S. Rao and Bhishm Kumar. 2012. Identification of Sources of Atmospheric Vapour using Isotopic Signature of Air Moisture at Roorkee, Uttarakhand, India. In: Proceedings of International conference on "Opportunities and Challenges in Monsoon Prediction in a Changing Climate" (OCHAMP-2012), Pune, India, 21-25 February 2012 at IITM,Pune. *www.tropmet.res.in/ochamp/extended_abstracts/.../OC-000101.pdf* **Reports** ➢ Presented the annual progress of the project in PRC meeting and submitted a copy of the report to Project Review Committee and funding agency (DST-SERC). **Trainings** ➢ 22 technical persons have been trained at various stages of the project. ➢ Under this project, a DST-SERC sponsored one week training workshop on Isotope Hydrology was conducted at NIH, Roorkee during 19-24 December 2011 attended by 60 participants. Some of the most eminent scientists and distinguished researchers from various organizations and research institutes, namely, PRL, BARC, NIH, SAC, IIT-Roorkee, NCAOR were invited as resource persons to deliver 30 lectures.
15	**Major items of equipment procured**	**:**	NIL
16	**Lab facilities used during the study**	**:**	Hydrological Investigations Division
17	**Data generated during the study**	**:**	Isotope database for stations at Roorkee, Sagar, Jammu, Kakinada, Kanpur, Tezpur and Manali
18	**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.

19 **Specific linkages with Institutions and/or end-users/beneficiaries** : **Participating Organization**s: AnnaUniversity, BARC, CGWB, CPCB, CWC, CWRDM, IMD, IIT-Kharagpur, NGRI, NIO, NRL-IARI, PRL

20 **Shortcomings / difficulties, if any** : The present sampling is getting done at ground level whereas meteorology includes high altitude atmospheric dynamics. Therefore, sample needs to be collected at various altitudes from ground to cloud level. The steps have been initiated to develop technology (use of Kytoons) towards collection of samples from various altitudes.

21 **Future plan** :

- Establishing a new station in Indo-Gangetic plains in Patna.
- The sampling of GLV, rain, river and groundwater will continue in this year.
- Scientific/technical publication/reporting in consultation with IWIN Secretariat.

Annexure_1

ACTIVITY SCHEDULE (Quarter wise from April 2012 to August 2013) for NATIONAL PROGRAM ON ISOTOPE FINGERPRINTING OF WATERS OF INDIA

Activity	1st	2nd	3rd	4th	5th	6th
Sampling from all stations (7) 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				♦	♦	♦

2. REFERENCE NUMBER: NIH/HID/INT/2009-12

1	**Title of the study**	**:**	SURFACE WATER AND GROUNDWATER INTERACTION AT SELECTED LOCATIONS ALONG RIVER YAMUNA IN NCT, DELHI (*Phase-II*)
2	**Name of PI, Co-PI, & their affiliations**	**:**	Dr. Sudhir Kumar, Scientist F (PI) Dr. M. S. Rao, Scientist E1 Mr. Pankaj Garg, Scientist B
3	**Type of study (sponsored /consultancy /referred /internal).**	**:**	Internal (Refinement of Phase-I study)
4	**Date of start, Scheduled date of completion**	**:**	1st April, 2009 31st March, 2012
5	**Location Map (wherever applicable)**	**:**	Study area lies in NCT Delhi near the border of Haryana and Uttar Pradesh. The floodplain is 1.2 – 1.5 km wide and is constraineded by embankments on both the sides.
6	**Study objectives (not more than 4)**	**:**	1. To study the surface water and groundwater interaction along river Yamuna in National Capital Territory of Delhi. 2. To determine the extent of surface water and groundwater interaction.
7	**Statement of the problem**	**:**	Ninety tube wells have been constructed in the floodplains of the river Yamuna to extract groundwater. These tube wells are apprehended to inducing recharge from the river. The study is aimed to study the surface water and groundwater interaction after the installation of tube wells.
8	**Approved action plan**	**:**	Please see Annexure 2 for activity schedule.

Year	**April to March**	**Remark**
All Years	Field investigations, Data Collection and Data analysis, Mathematical Modelling based on Isotopic results	Report preparation after three years

9	**Timeline and justification for time over runs**	**:**	NA

10 **2-column table showing objectives vis-à-vis achievements** (clearly separate achievements reported in the previous meetings)**:**

Objective	**Status**	**Work Done**
To study the surface water and	Achieved	Sampling for isotopic analysis and

groundwater interaction along river Yamuna in NCT, Delhi.		water level monitoring completed. Mathematical model for groundwater modelling is under calibration.
To determine the extent of surface water and groundwater interaction.	Achieved	

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

12 **Analysis and Results** :

i) Recharge in the floodplain upto 3.52 meters during floods.
ii) Lateral interaction of the river only upto 200 – 250m. After this, the interaction of river is not significant.
iii) Vertical recharge in the floodplains takes place only for 15-20 days in a year

The other details along with interpretation of the data will be presented during the meeting.

13 **Adopters of the results of the study and their feedback** : Delhi Jal Board and Upper Yamuna River Board

14 **List of deliverables** (e.g. equipment, papers, reports, software, manuals, brochures, flyers, training programmes, users interaction workshops) : Report and Paper

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

16 **Lab facilities used for study** : Isotope Ratio Mass Spectrometer

17 **Data procured and/or generated during the study** : Isotopic data and water level data at 13 locations within the Yamuna floodplain in Palla area

18 **Study Benefits / Impact** (2-column table showing achievements against measurable indicators as mentioned in the approved study document) : Quantification of the groundwater recharge from Yamuna river

19 **Specific linkages with Institutions and/or end-users/beneficiaries** : Upper Yamuna River Board and Delhi Jal Board

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

21 **Future plan** **:** The project shall be completed by 30th April 2012.

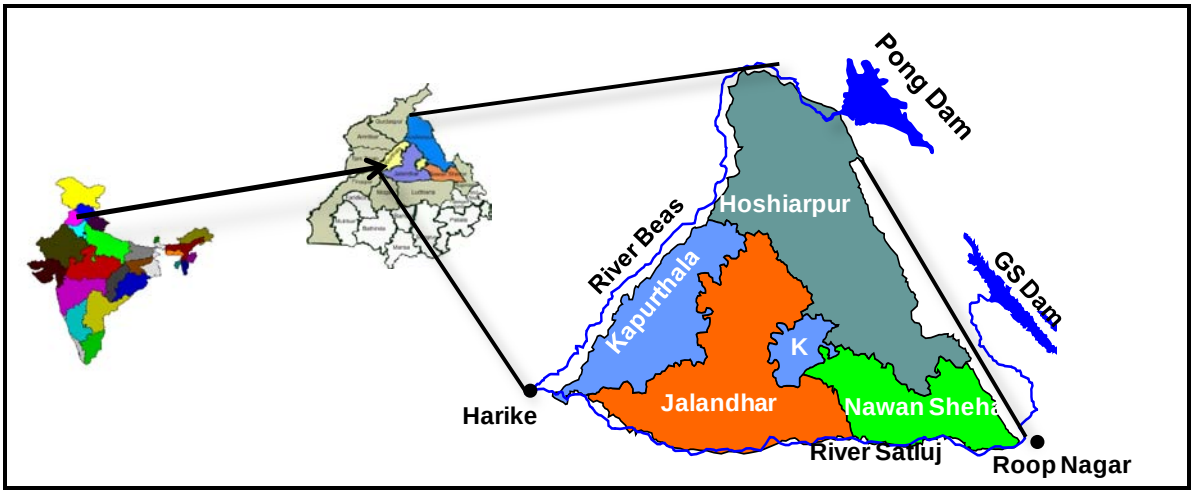
Annexure-2

ACTIVITY SCHEDULE (Quarter wise) for SURFACE WATER AND GROUNDWATER INTERACTION AT SELECTED LOCATIONS ALONG RIVER YAMUNA IN NCT, DELHI (*Phase-II*)

Activity	1st	2nd	3rd	4th	Primary Responsibility
Collection of all required data	♦				DJB / CGWB
Compilation of existing hydrogeological data	♦				DU / CGWB
Identification of data gaps	♦				NIH+ others
Identification of wells for water level monitoring	♦				CGWB
Establishment of field stations, if required	♦	♦			CGWB
Infiltration tests	♦				NIH / IITD
Identification of wells for WQ monitoring	♦				IITD
RL Survey of GW wells	♦				CGWB
Groundwater level monitoring	♦	♦	♦		CGWB
Pump Tests to determine specific yield and hydraulic conductivity / transmissivity		♦			CGWB
Collection of SW and GW samples for water quality and/or isotopic analysis		♦	♦		CGWB / IITD / NRL
Survey to determine groundwater draft/ any other relevant information from FP		♦	♦		CGWB
Development of aquifer geometry in and around YFP			♦		DU / CGWB
Analysis of water quality of SW and GW samples		♦	♦		DPCC / CPCB
Analysis of stable isotopes (δD and $\delta^{18}O$) of SW and GW samples		♦	♦		NIH
Assessment of GW resources of the Yamuna FP in NCT Delhi			♦		CGWB / NIH
Estimation of natural recharge to groundwater			♦		CGWB / NIH
Determination of groundwater flow direction in reference to river Yamuna			♦		NIH
Delineation of groundwater contaminated areas with in floodplain			♦		IITD
Identification of areas suitable for GW abstraction w.r.t. water quality			♦		IITD
Creation of GIS data base for GW modelling					NIH
Development of conceptual model			♦		All
Calibration of model			♦		All
Development of GW extraction scenarios			♦		NRL / IITD
Simulation of impact of GW abstraction on SW and GW resources			♦		NIH / IITD
Simulation of groundwater recharge in the Yamuna FP from Monsoon Floods				♦	NIH / CGWB
Report finalisation				♦	All

3. PROJECT REFERENCE CODE: NIH/HID/HP-II/09-12

1	**Title of the study**	**:**	GROUNDWATER DYNAMICS OF BIST DOAB AREA, PUNJAB, USING ISOTOPES (PDS UNDER HP-II)
2	**Name of PI, Co-PI, & their affiliations**	**:**	Dr. M. S. Rao (PI) Bhishm Kumar Sudhir Kumar S. K. Verma PankajGarg CGWB Officials
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**	**:**	1st July, 2009 30th June, 2012
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 parts 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** : See Annexure-3

9 **Timeline and justification for time over runs** : NA

10 **2-column table showing objectives vis-à-vis achievements** (clearly separate achievements reported in the previous meetings) :

Objective	Status	Work Done
Identifying groundwater recharge zone and recharge sources using groundwater dating and stable isotope technique	Recharge sources & zones of shallow and deep groundwater have been refined.	837 samples (SW, GW & Rain) have been collected after last WG (Oct. 2011 to Feb. 2012) making total of 3057 samples collected during the entire study period. The rain water and shallow groundwater samples (583+224 respectively) have been analyzed for better refinement of identifying the recharge sources. Groundwater quality for drinking and agricultural purposes has been examined for Jalandhar and

and groundwater modelling		Kapurthala districts. On the basis of isotopic and conventional data, physical understanding of groundwater flow conditions has been developed.
	In progress	The data (including AWLR from 6 stations) and phenomenological understanding of groundwater flow will be integrated for hydrological modelling of the study region.

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

Suggestion: Dr. S. S. Grewal (Retd. Dir., PAU) suggested to confirm possibility of recharge to groundwater due to seepage from canal from Balachore to Nawanshahr, as observed in the earlier studies based on selenium analysis. He also suggested to investigate using isotopic technique the reason for the observed groundwater in rising conditions in Kandi area.
Action: Regarding selenium observations, samples have been collected for selenium and isotopic analysis over the stretch from Balachore and Nawanshahr. The collected samples will be analyzed for selenium using the recently procured Ion Chromatograph (which will be installed within a couple of months). The isotopic data confirms the linkage between canals and shallow groundwater between Balachore and Nawanshahr.
Suggestion: Dr. R. C. Jain, CGWB commented: the isotopic data indicates the deeper aquifers are in confined to sub-confined conditions that need to be substantiated using pumping test and hydro-geological conditions.
Action: The pumping test carried out by CGWB at deeper aquifer at Lallian Kalan during Feb-2012 clearly shows that the deeper aquifer is confined and does not have any inter connection with medium and shallow aquifer.

12 **Analysis and Results :**
Isotopic characterization of sources

On the basis of water sampled from different types of water sources of the study area, the isotopic characteristic of these sources have been deciphered and these are given in Table 1. The inferences drawn from these isotopic characteristic equations are:

The deep groundwater gets

Table 1. Isotopic characterization of sampled water

Sampled Water Type	**Equation** (Refined using the new data set)
Precipitation (All)	$\delta D = 7.86 \times \delta^{18}O + 5.44$; $R^2 = 0.96$; n= 148
Precipitation (At Kandi)	**$\delta D = 7.85 \times \delta^{18}O + 5.82$; $R^2 = 0.98$; n= 73**
Precipitation (At Plain)	$\delta D = 7.87 \times \delta^{18}O + 5.07$; $R^2 = 0.98$; n= 75
River Beas	$\delta D = 7.57 \times \delta^{18}O + 8.56$; $R^2 = 0.90$; n= 56
River Satluj	$\delta D = 6.75 \times \delta^{18}O - 2.61$; $R^2 = 0.94$; n= 76
Shallow Groundwater	$\delta D = 6.54 \times \delta^{18}O - 2.83$; $R^2 = 0.96$; n= 159

recharge mainly through Kandi canal which is evidenced from the similar regression equation of precipitation at Kandi region and deep groundwater.

The shallow groundwater gets recharged (fig. 1.) mainly through precipitation and to minor extent from the river Beas, Kandi Canal and Bist-Doab canal in the adjoining areas (few 100m).

Water Chemistry of District Jalandhar and Kapurthala

The groundwater type in Jalandhar and Kapurthala districts are: $CaMgHCO_3$ (shallow aquifer) $CaMgHCO_3$ & $NaHCO_3$ (medium aquifer) $NaHCO_3$ (deep aquifer) (Fig. 2).

Sodium Hazard

The US Salinity Laboratory diagram for groundwater of the study region shows that (fig 3.) groundwater in the medium and deep aquifers of Kapurthala and Jalandhar districts falls mostly on the C2S1 indicating quality of groundwater fairly good for irrigation needs. Three samples in the deep aquifer falling on C2S2 field shows moderate quality and almost all the samples in shallow aquifer and one sample in medium aquifer falling on C3S1 indicate moderate quality.

Sodium Percentage

The high concentration of sodium in soil releases calcium and magnesium in the soil particles due to absorption of sodium in clay particles.

Deep Groundwater	$\delta D = 7.73 \times \delta^{18}O + 5.63$; $R^2 = 0.95$; n= 111

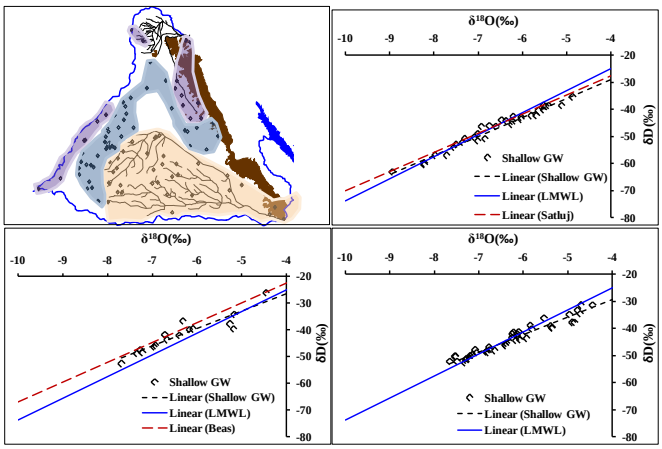


Fig. 1 Recharge source identification of shallow groundwater using stable isotope

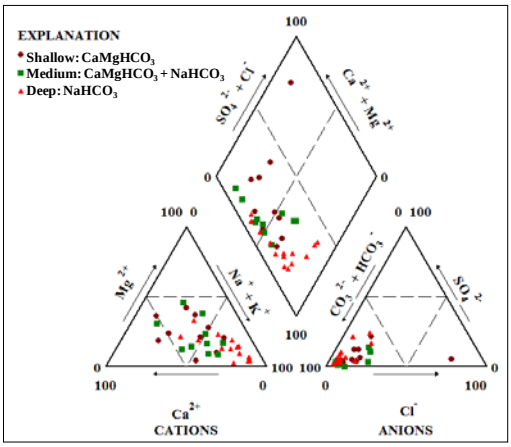


Fig. 2 Piper Diagram: Classification of groundwater

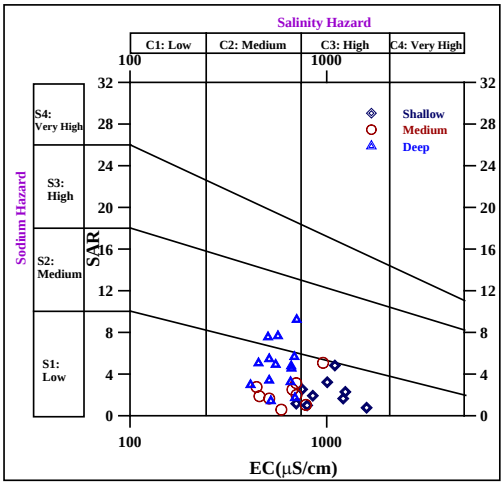


Fig. 3 Water classification according to SAR and EC

Sodium reacts with soil and as a result clogging of particles takes place, thereby reducing the permeability. The EC vs Na% (Fig. 4) plot shows that groundwater samples in the shallow aquifer show good to permissible nature. The medium and most of the deep aquifer samples show excellent to good nature with few deep aquifer samples showing good to permissible nature (Fig. 4).

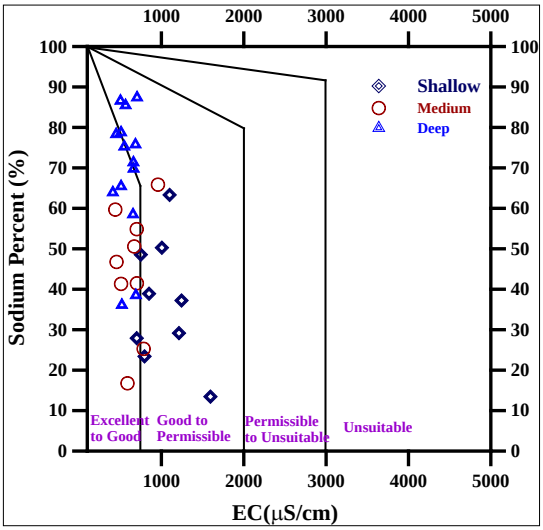


Fig. 4 Classification of irrigation waters

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) :

- Stable isotopic characterization of groundwaters in Bist-Doab region, Punjab. (2011). *National conference in advanced techniques in civil engineering, B.H.U, India*
- Hydrochemical and isotopic evidence of groundwater for its evolution and source in Jalandhar and Kapurthala district. (2011). *Submitted in Journal of Earth System Sciences*

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

16 **Lab facilities used during the study** : Lab 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 lab analysis. Water level data generated through AWLR installed in peizometers at 6 locations in the study area.

18 **Study Benefits / Impact** (2-column table showing achievements against measurable indicators as mentioned in the approved study document) : 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** : CGWB (NWR), Chandigarh; Punjab Water Resources

	Institutions and/or end-users/beneficiaries		Development & Management and 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**	**:**	• Construction of deep peizometers • Analysis of samples collected for water chemistry using ion chromatograph (to be installed during the 2nd quarter) • Aquifer disposition map • Groundwater modeling. • Final report and publication of research articles in journals & conferences. • Organisation of training program in the 2nd quarter of 2012.

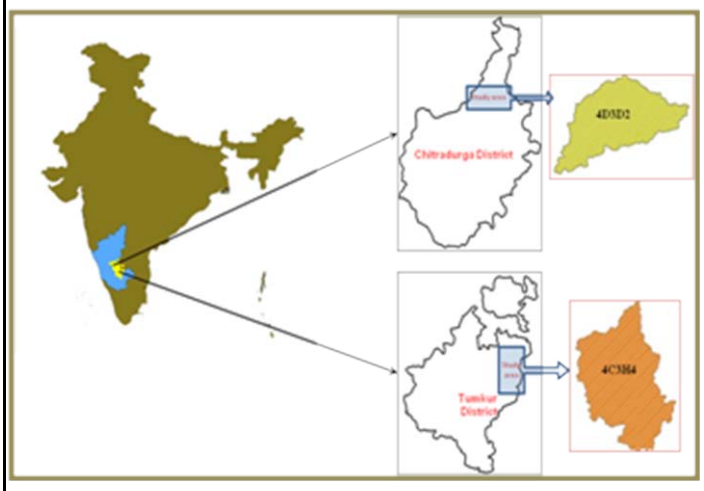
Annexure-3

ACTIVITY SCHEDULE for GROUNDWATER DYNAMICS OF BIST DOAB AREA, PUNJAB, USING ISOTOPES (PDS UNDER HP-II)

Activity	Apr. 2012 - Mar. 2013			
	1st	2nd	3rd	4th
Collection of field related data (Rainfall and groundwater level)	✓	✓		
Sample collection of groundwater, surface water, precipitation and AWLR data	✓	✓	✓	
Surface water and groundwater data processing	✓	✓	✓	
Procurement of software		✓		
Construction and installation of piezometers at 6 locations (3 at Kandi and 3 at Plain region)	✓	✓		
Groundwater modelling		✓	✓	
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	✓	✓	✓	
Organising training program		✓		
Preparation of final report and publications			✓	✓

4. PROJECT REFERENCE CODE: NIH/HID/HP-II/09-12

1	**Title of the study**	:	GROUNDWATER MANAGEMENT IN OVER-EXPLOITED BLOCKS OF CHITRADURGA AND TUMKUR DISTRICTS OF KARNATAKA
2	**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, NIH,Belgaum Prof. C. Rangaraj, SSIT, Tumkur
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**	:	1st July 2009 30st June 2012
5	**Location map** (wherever applicable)	:	



District	**Tumkur**	**Chitradurga**
Talukas	Kortagere (80%) Tumkur (20%)	Challakere (93%) Molakalmuru (7%)
Watershed	4C3H4	4D3D2
Latitude	$13^0 14' - 13^0 44' N$	$14^0 17' - 14^0 34' N$
Longitude	$77^0 02' - 77^0 28' E$	$76^0 22' - 76^0 49' E$
Area	89846 ha	64843 ha
Elevation	618-1261 m	461-902 m
Basin	Pennar Basin	Lower Tungbhadra
Main Stream	Suvarnamukhi	Garani Halla
Geology	Granitic Gneiss	Gneiss, Schist
Stage of GW development	233 %	140%
Command / Non Command	Non Command	Non Command
Agroclimatic zone	Central and Eastern dry zone	Central dry zone
Soils	Red sandy soil and Red loamy soil	Red loamy soil

6	**Study objectives (not more than 4)**	:	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.

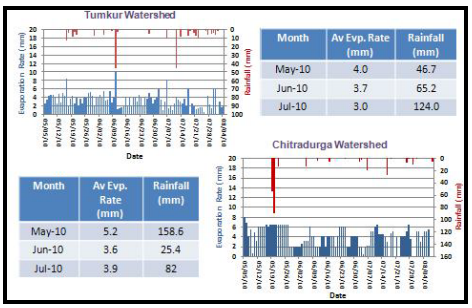
v) To arrive at a model for management and regulation of identified over-exploited blocks on an operational basis.

7	**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.
8	**Approved action plan**	**:**	*Please see Annexure 4*
9	**Timeline and justification for time over runs**	**:**	The procurement of data and instruments has delayed the work schedule.
10	**2-column table showing objectives vis-à-vis achievements** (clearly separate achievements reported in the previous meetings)	**:**	

Objective	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

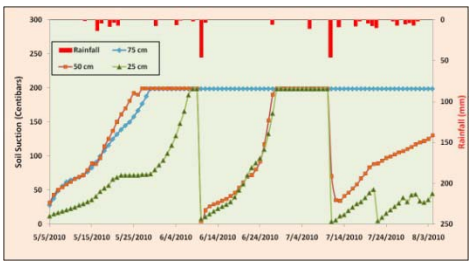
11 **Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken** : No specific comments were made.

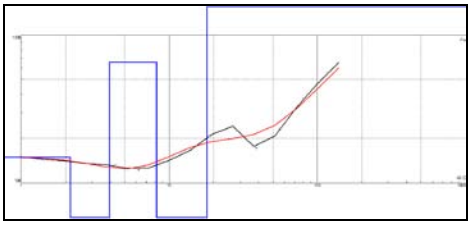
12 **Analysis and Results** :



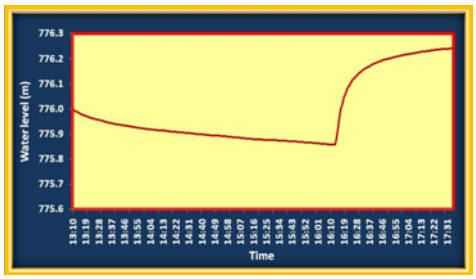
Month	Av Evp. Rate (mm)	Rainfall (mm)
May-10	4.0	46.7
Jun-10	3.7	65.2
Jul-10	3.0	124.0

Month	Av Evp. Rate (mm)	Rainfall (mm)
May-10	5.2	158.6
Jun-10	3.6	25.4
Jul-10	3.9	82





- Hydrometeorological instruments (evaporation pan, soil moisture sensors and rain gauge) and automatic groundwater level recorders installed in the field.
- GIS Database has been prepared for both the watersheds including base map, drainage map, road map and water storage structures map etc.
- Infiltration tests conducted at 16 locations in both the watersheds. Low infiltration rates in the bottom of tanks indicating chocking of tank beds.
- Water level data (depth to water level and reduced water level) and rainfall data have been collected for about 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 35 groundwater samples from Chitradurga and Tumkur watersheds have been collected and analyzed 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 at 4 locations. The results indicate low hydraulic conductivity.
- Socio-economic survey has also been conducted.

13	**Adopters of the results of the study and their feedback**	:	Karnataka Government, the states with hard rock aquifers
14	**List of deliverables** (e.g. equipment, papers, reports, software, manuals, brochures, flyers, training programmes, users interaction workshops)	:	Report, papers, methodology, brochure and training program
15	**Major items of equipment procured**	:	Automatic Rain Gauges, Automatic Groundwater Level Recorders
16	**Lab facilities used during the study**	:	Isotope lab, Soil Water lab and Hydrological Instrumentation lab
17	**Data procured and/or generated during the study**	:	Remote Sensing data
18	**Study Benefits/Impact**	:	
19	**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.
20	**Shortcomings / difficulties, if any**	:	Delay in procurement of data and instruments Lack of historical data and reliability of data.
21	**Future plan**	:	As per activity chart

Annexure-4

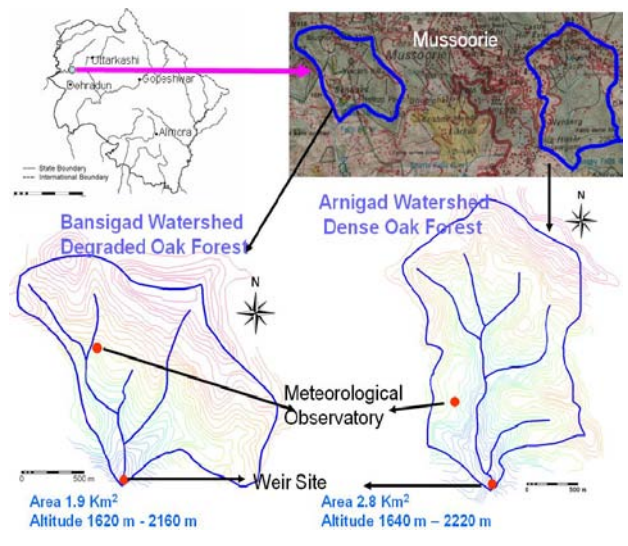
ACTIVITY SCHEDULE (Quarter wise) for GROUNDWATER MANAGEMENT IN OVER-EXPLOITED BLOCKS OF CHITRADURGA AND TUMKUR DISTRICTS OF KARNATAKA

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Selection of watersheds	♦	♦										
Reconnaissance surveys		♦	♦									
Data collection (Historical)		♦	♦									

Activity	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**
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 GW utilization guidelines										♦	♦	
Capacity building and training programs								♦	♦			♦
Report writing											♦	♦

5. PROJECT REFERENCE CODE: NIH/HID/FRI/08-13

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 Dr. Bhishm Kumar Dr. J. V. Tyagi Mr. M. P. Singh, FRI Rajeev Tiwari, IGNA Mr. Vishal Gupta Mr. Jamil Ahmad Mr. V. K. Agarwal
3	**Type of study (sponsored/ consultancy/ referred/ internal).** If referred, mention the reference	:	Collaborative with FRI, Dehradun Total: 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 watershed	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 ground water components in the stream discharge using conventional and isotopic technique
- Soil erosion under different forest cover

- Identification of recharge zone of stream and springs using isotopic technique.

7 **Statement of the problem** **:** Efforts to understand the hydrology of the Himalayan region and impact of forests on watershed level are limited. Studies on the 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. Because 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 5*

9 **Timeline and justification for time over runs** **:** NA

10 **Objectives vis-à-vis achievements** **:**

Objective	Achievement
Impact of forest cover on stream discharge pattern	Data collection completed and analysis under progress.
To separate surface runoff and groundwater components in the stream discharge using conventional and isotopic techniques	Using conventional technique, surface runoff and groundwater component is computed. Isotopic analysis under progress.
Soil erosion under different forest covers	Data under analysis
Identification of recharge zone of stream and springs using isotopic technique	Isotope technique has been used to identify the recharge zones of springs and streams

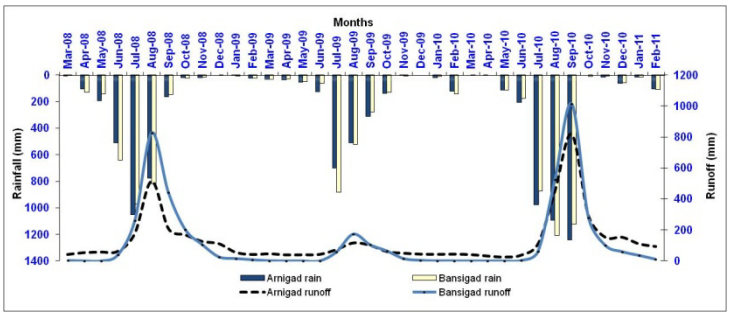
11 **Recommendations/suggestions in previous meetings of Working Group/TAC/GB should be mentioned along with the action taken** **:** NIL

12 **Analysis and Results** **:**

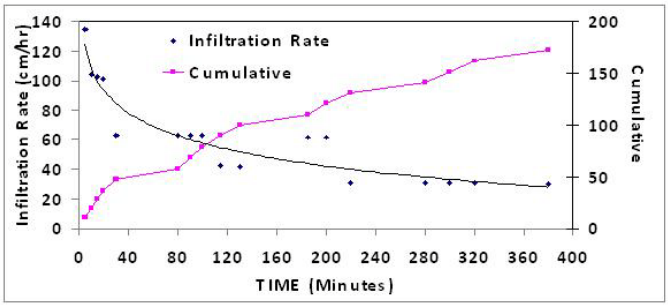
- Hydrometeorological data

collection of the both watersheds is completed.

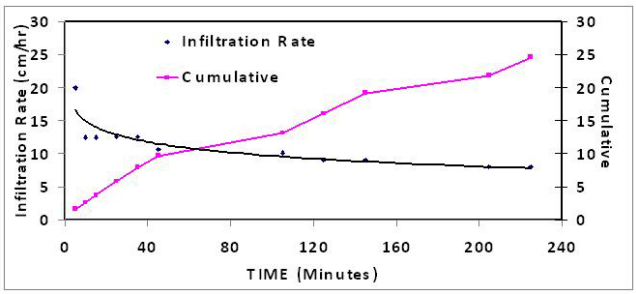
- The continuous data have been recorded from June 2008 to Feb. 2011.
- Samples of streams, springs and handpump have been collected for isotopic analysis and details will be presented in the working group.
- Data of infiltration tests have been analyzed under different land use conditions.
- Analysis of soil moisture variation has been completed.
- Analysis of sediment data is completed.
- Rainfall and runoff on the monthly basis has been analyzed.
- Recharge to groundwater in both watersheds has computed.
- Rainfall-Runoff and soil loss modeling using SWAT model is in progress.
- The analysis of soil moisture data revealed large variations in soil moisture storage at different sites and depths and also during different seasons in each of the study watersheds.
- The profile analysis indicated highest soil moisture content in shallow profile which decreased with depth in both the watersheds. A high positive correlation was found between tree density and soil moisture content.



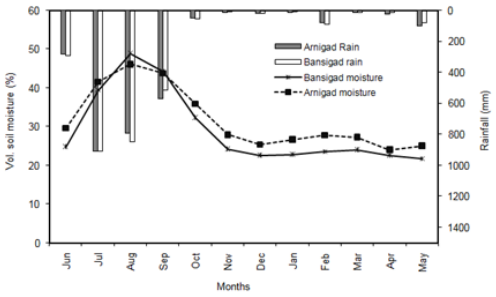
Rainfall-Runoff of both watersheds



Infiltration rate in dense forest cover



Infiltration rate in degraded land



Soil moisture variation in degraded and dense forest cover area

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

14 **List of deliverables** (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users : Papers

interaction workshops)

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

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

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

18 **Study Benefits / Impact** :

Activity	Status
Selection of two watersheds under under different forest cover	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	Under progress
Assessment of impact of forest cover on stream discharge	Under progress
Assessment of impact of forest cover on erosion	Under progress
Estimation of sediment erosion using the SWAT model	Under progress

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

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

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

Annexure – 5

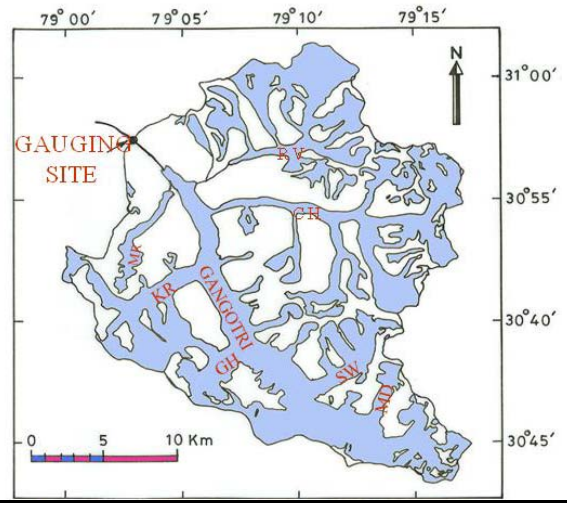
ACTIVITY SCHEDULE (Quarter wise, for 2011-12 and 2012-2013) for Impact Assessment of Landuse on the Hydrologic Regime in the Selected Micro-Watersheds in Lesser Himalayas, Uttarakhand

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 $\delta^{18}O$)	♦	♦	♦	♦				

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

6. 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 Dr. Manohar Arora Dr. Bhishm Kumar Dr. Rakesh Kumar Mr. Naresh Kumar Mr. Jamil Ahmad Mr. Vishal Gupta
3	**Type of study** (sponsored/ consultancy/ referred/ internal). If referred, mention the reference	:	Internal
4	**Date of start, scheduled date of completion**	:	April 2010 to Mach 2013
5	**Location map** (wherever applicable)		



Glacier Type	**Valley**
Elevation Range	4000-7000 m
Length	30 km
Width:	~0.2 to2.35 km
Total Area: Glacerized 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 Indian 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 meltwater which will be useful in separation of various components of stream discharge and in long term will be useful to understand the source of moisture and impact of climate change on melting patter.

8 **Approved action plan** : *Please See Annexure 6*

9 **Timeline and justification for time over runs** : NA

10 **2-column table showing objectives vis-à-vis achievements** (clearly separate achievements reported in the previous meetings) :

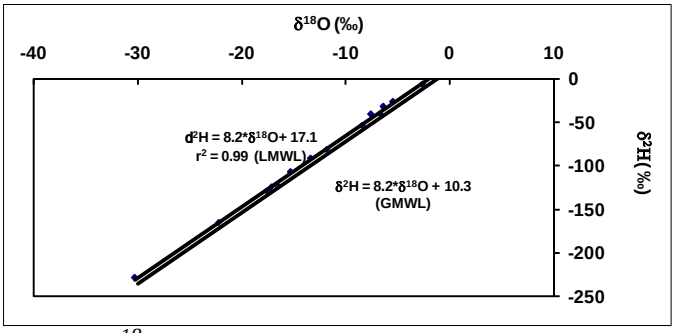
Objective	Achievement
Isotopic characterization of melt water and individual components (snow-glacier melt, groundwater, rainfall-runoff).	Samples are collected for the ablation period 2010 and sampling for 2011 continued.
Estimation of snow and glacier melt contribution separately and its variability with time.	Isotopic characterization of rainwater has been carried out. Isotopic characterization of snow and glacier under progress. Isotopic characterization of meltwater under progress.

11 Recommendations/suggestions in previous meetings of : NIL

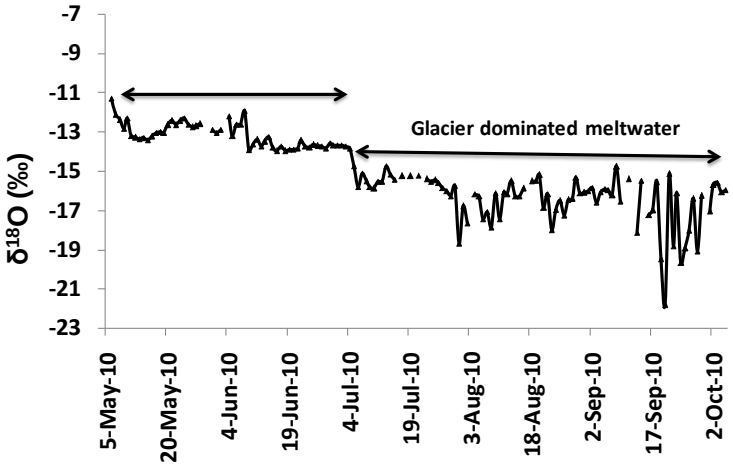
Working Group/TAC/GB should be mentioned along with the action taken

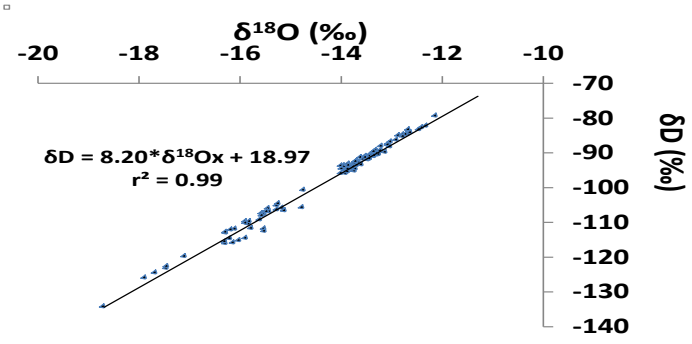
12 Analysis and Results :

- The plot of δ^2H versus $\delta^{18}O$ for all precipitation samples collected during the ablation period of 2004 and 2008. The Local Meteoric Water Line (LMWL) developed as δ^2H = 8.2 (±0.10) x $\delta^{18}O$ + 17.1 (±1.53) (n = 15, r2 = 0.99) for a complete ablation period which is showing higher slope and y intercept in comparison to GMWL.
- The isotopic signature of the fresh snow and surface ice of different altitudes in the accumulation and ablation zones of the Western Himalayas reported by various workers and found under the present study are between -4.5‰ and -14‰ for snow and -13‰ to -25‰ for glacier.
- 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‰.
- 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 Gomukh site and the best fit line is $\delta^2H=8.2*\delta^{18}O + 18.97$ r^2 = 0.99, n = 110 (2010).
- Attempt has been made to separate the snow and glacier contribution.



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 ablation period 2010

- The détails 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** (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users interaction workshops) : Paper presented in International conference at Monaco, organized by IAEA.

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 snow, ice, meltwater and rainfall at the altitude of 3800 m.

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

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	Continued
Compilation of the results	In progress

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

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

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

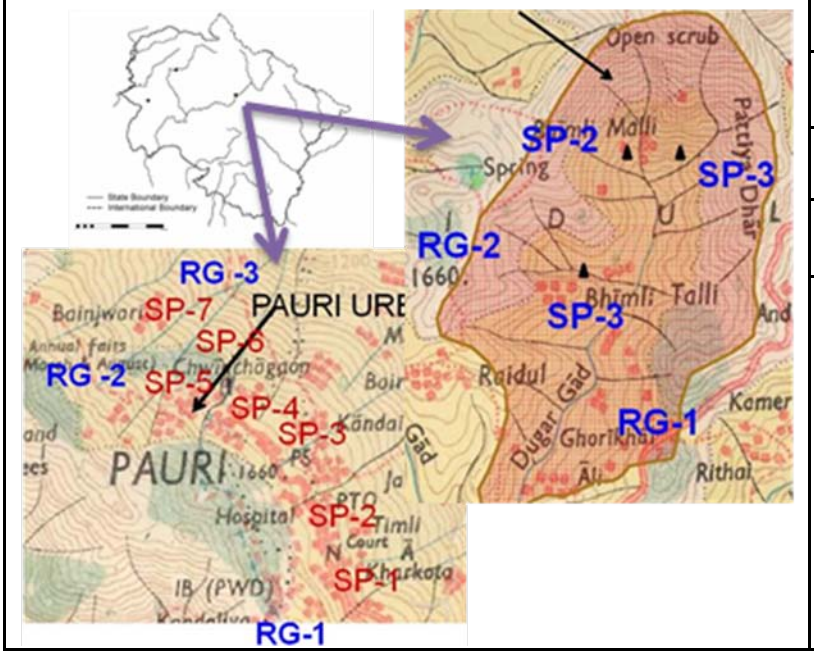
Annexure – 6

ACTIVITY SCHEDULE (Quarter wise, for 2011-12 and 2012-2013) for Estimation of Snow and Glacier Melt Contribution in Melt Water of Gangotri Glacier at Gaumukh Using Isotopic Techniques

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 component of meltwater using the isotope model				♦	♦	♦	♦	
First draft report						♦		
Second draft report							♦	
Final report								♦

7. REFERENCE NUMBER: NIH/HID/INT/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 Dr. Bhishm Kumar Dr. Sudhir Kumar Dr. S. D. Khobragade Mr. Pankaj Garg 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)		



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** **:** Ground water 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 zones. 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 did water originates?
- ❖ 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 7*

9 **Timeline and justification for time over runs** **:** NA

10 **2-column table showing objectives vis-à-vis achievements** (clearly separate achievements reported in the previous meetings) **:**

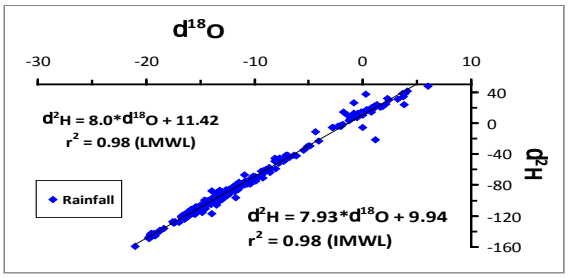
Objective	Achievement
To decipher the recharge zone of springs falling in the study area	Springs have been selected from different parts of Pauri and Dugargad watershed. Preparation of Hydrogeological mapping under progress.
To analyze the relationship between rainfall, evaporation, landuse/land cover and ecological factors with spring discharge	Raingauges and evaporation pans have been installed.
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** **:** NIL

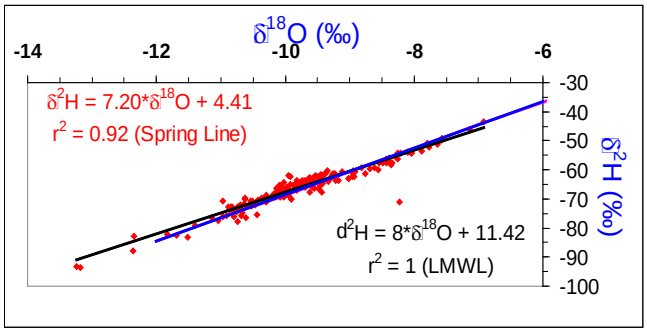
should be mentioned along with the action taken

12 **Analysis and Results** :

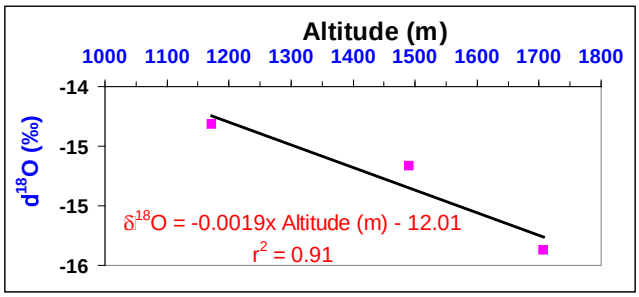
- The plot of δ^2H versus $\delta^{18}O$ for rainfall samples collected during June to September 2010 show the Meteoric Water Line (spring) as δ^2H = 8.0 x $\delta^{18}O$ + 11.4 which is similar to IMWL .
- The plot of δ^2H versus $\delta^{18}O$ for all springs samples collected during June to September 2010 show the Meteoric Water Line (spring) as δ^2H = 7.20 x $\delta^{18}O$ + 4.41 which is very close to LMWL.
- Temporal variation of isotopic data of springs of Dugargad watershed shows the depletion after the July and maximum depletion is in the month of September. It indicates quick response of recharge in the springs.
- Similarly, spring 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** : Uttarakhand Jal Sansthan

14 **List of deliverables** (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users : Report and paper

interaction workshops)

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

16 **Lab facilities used** : 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 :

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

Annexure – 7

ACTIVITY SCHEDULE (Quarter wise, for 2011-12 and 2012-2013) for Development of Spring Sanctuaries in an Urban and a Rural Watershed in District Pauri Garhwal, Uttarakhand

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			♦	♦		♦	♦	

Activity	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**
Estimation of recharge zones of spring					♦	♦		
Formulation of strategies for development of spring sanctuaries						♦	♦	
First draft report						♦		
Second draft report							♦	
Final report								♦

8. REFERENCENUMBER: NIH/HID/INT/10-12

1. **Title of the study :** IDENTIFICATION OF RECHARGE ZONES OF SOME SELECTED SPRINGS OF UTTARAKHAND USING ISOTOPES

2. **Study Team** : Dr. S. D. Khobragade
Dr. Bhishm Kumar
Dr. Sudhir Kumar
Dr. S. P. Rai
Mr. Pankaj Garg

3. **Type of study** : Referred (study has been taken up on the request of Uttarakhand Jal Sansthan, Dehradun)

4. **(i) Date of start** **:** April, 2010
(ii) Scheduled date of completion **:** March, 2012.

5. **Study area:**

Four springs namely Ratoli, Moli, Gothiyara and Kandha Dhangi, located in the Chandrabhaga watershed in Jakhanidhar block, Devprayag in Tehri Garhwal district of Utarakhand in the catchment of river Bhagirathi have been selected for study. The springs have been suggested by the Uttarakhand Jal Sansthan Authorities, Dehradun. The discharge of the springs is known to have reduced considerably over the past few years. The terrain of the study area is highly rugged and hilly with steep slopes. The altitude varies from 800-2300 m. The Ratoli spring is located at 2140 m, Moli Spring at 1942 m, Gothoyara Spring at 1872 m and the Kandha Dhangi spring at 1005 m altitude. The geological formation of the study area consists of greenish grey slaty and schistose phyllite inter-bedded with quartzite. The soils are generally shallow, varying in texture and depth.

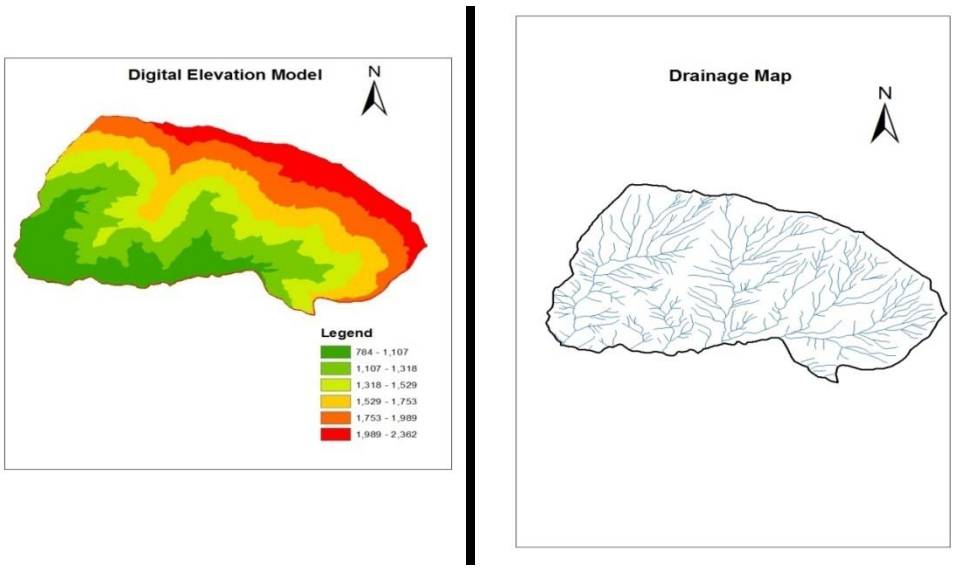


Fig. 1: Study area

6. Study objectives

- To identify the recharge areas of some selected springs of Uttarakhand
- To suggest remedial measures for the rejuvenation of these springs

7. Statement of the problem

There are a number of springs in Uttarakhand which are facing problem of reduction in discharges over the years. A request has been received from Uttarakhand Jal Sansthan, Dehradun to study the springs of about 10 districts which are the only sources of water in their respective regions, so that conservation and management measures can be suggested for these springs based on scientific investigations. However, keeping in view the feasibility, only a few springs (four from Tehri Garhwal district) have been taken up in the first phase for investigations related to identification of the recharge areas and to suggest remedial measures for their rejuvenation.

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

9. Timeline and justification for time overruns: Not applicable

10. Achievements vis-à-vis objectives:

Objective	Achievement
i) Collection of rainfall and discharge data	Completed
ii) Collection and laboratory analysis of water samples from rain, springs and hand pump	Samples collection is completed. Analysis of some samples are remaining.
iii) Analysis of response of spring to rainfall	Completed
iv) Establishment of altitude effect for the study area	Completed
v) Identification of recharge areas of springs	Under progress
vi) Remedial measures for rejuvenation of the springs	Remaining

11. Recommendations/suggestions in previous meetings of Working Group/TAC/GB along with the action taken:

No specific suggestion.

12. Analysis and Results

- Discharge data for the four springs have been monitored at a 15 days interval during 1 June, 2010 to 15 June, 2011 and at weekly interval from July, 2011 to January, 2012. The discharge data of the springs indicates that the Moli spring is the only sustainable of all the four study springs. Although its discharge reduces significantly during February to July, it still has a minimum discharge within a range of 0.5 to 1.0 lps during this period also. The Kandhadhangi spring on the other hand exhibits the lowest discharge among all

the four study springs. This spring goes completely dry during March to June. The Ratoli and Gothiyara springs also exhibit low discharges for most months except for July to November.

- Analysis of the variation of rainfall versus-spring discharge indicates a delayed response of the springs to the rainfall as far as discharge is concerned. However, the response time of different springs vary.

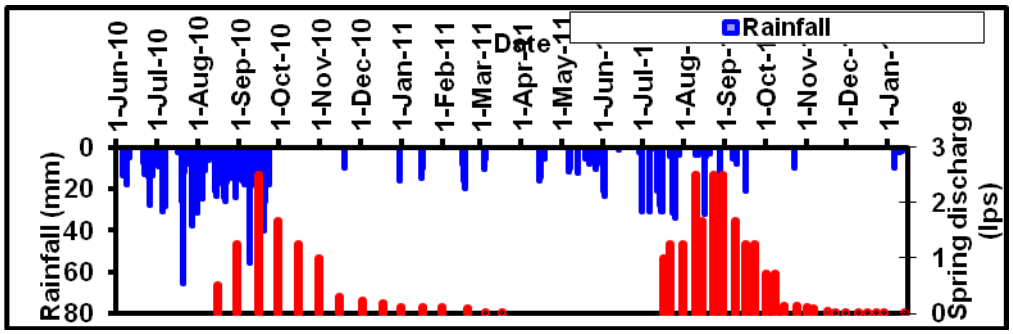


Fig. 2 Variation of spring discharge with rainfall for Kandha Dhangi Spring

- Analysis of the δ-O18 data of the three locations indicate that the area receives some local rainfall during October to mid July and the isotopic signatures are enriched. The enrichment is especially more during the summer months of April to June, indicating effect of evaporation. However, heavier rainfall received thereafter during the monsoon causes depleted isotopic signatures.

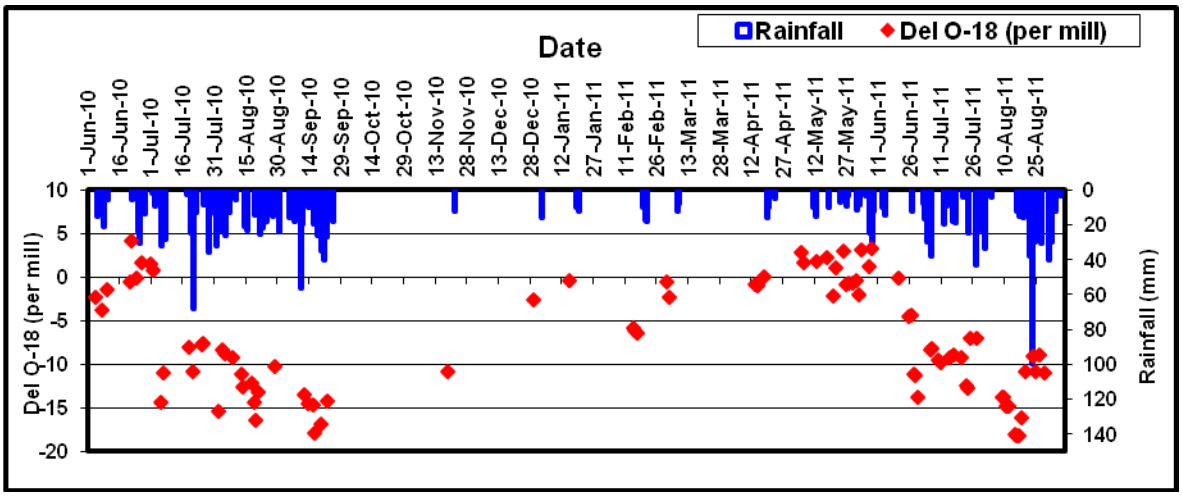


Fig. 3 Variation of del O-18 of precipitation data for Anjanisain

- Altitude effect has been established for del O-18. Following equation has been obtained:

$Y = -0.00227X - 6.3365$ ($R^2 = 0.83$) where, Y is the isotopic value of the precipitation and X is altitude. The variation in del O-18 values comes out to be -0.27 per 100 m. Using this equation, the recharge altitudes for various study springs would be established. The work is under progress.

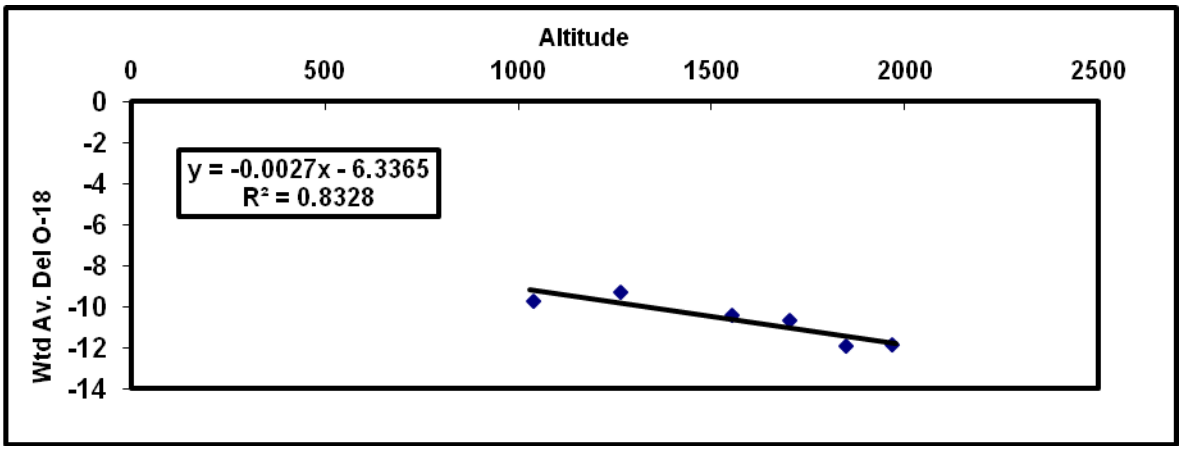


Fig. 4 Altitude effect for del O-18.

Based on the altitude effect established for the study area, identification of recharge altitudes is in progress. Hydro-geological data of the area is also being taken into consideration for the purpose. However, some difficulties are being faced in interpretation of the data. Interaction with the former Head, Dr. Bhishm Kumar is going on. The work is expected to be completed by March, 2012 end. The detailed results would be presented in the working group meeting.

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

The main adopter of the results of the study would be Uttarakhand Jalsansthan, Dehradun. Feedback will be received after the final results are communicated to them.

14. List of deliverables

i) Report with recommendations for the recharge of springs
ii) Rainfall, discharge and isotopic data
iii) Research papers
iv) Interaction workshop with Uttarakhand Jal Sansthan authorities

15. Major items of equipment procured

None. Minor equipment like raingauges, temperature meter, humidity meter, etc. have been procured.

16. Lab facilities used during the study

Nuclear Hydrology Lab and Remote sensing Lab.

17. Data procured and/or generated during the study

i) Rainfall data
ii) Spring discharge data
iii) Isotopic data for rainfall, springs and ground water

18. Study Benefits / Impact (showing achievements against measurable indicators)

Indicator	Achievements
Collection of rainfall data at different altitudes	Completed
Collection of discharge data of spring	Completed
Collection of spring water, groundwater and rain water samples for isotopic analysis	Completed
Laboratory analyses of the collected water samples	Under progress for samples collected after Sep., 2011
Interpretation of collected data	Remaining for samples collected after Sep., 2011
Development of local meteoric line	Completed
Establishment of altitude effect	Completed
Identification of recharge altitudes for different springs	Under progress

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

The study has been taken up on the request of the Uttarakhand Jal Sansthan, Deharadun.

20. Shortcomings/difficulties, if any

i) I am still to develop detailed and adequate understanding of the science of isotope hydrology (interaction with Dr. Bhishm Kumar, former Head, HID and his technical assistance is hence inevitable for completion of study).

21. Future plan:

Identification of recharge zones and recharge structures for the study springs and interaction with the Jal Sansthan authorities

Annexure-8

ACTION PLAN AND TIMELINE FOR THE STUDY ON IDENTIFICATION OF RECHARGE ZONES OF SOME SELECTED SPRINGS OF UTTARAKHAND USING ISOTOPES

Activity	Q-1	Q-2	Q-3	Q-4	Q-5	Q-6	Q-7	Q-8
Finalization of springs	♦							
Procurement of equipment like raingauge, temp. meter, humidity meter etc.	♦							
Installation of raingauges	♦							
Engaging data observers for collection of raingall, discharge, temperature data etc.	♦							
Collection of water samples from spring, rainfall and handpumps for isotopic (δD and $\delta^{18}O$)	♦	♦	♦	♦	♦	♦		
Collection of available data/review of literature/preparation of maps etc.	♦	♦	♦	♦	♦	♦		
Laboratory analysis of water samples	♦	♦	♦	♦	♦	♦	♦	

Activity	**Q-1**	**Q-2**	**Q-3**	**Q-4**	**Q-5**	**Q-6**	**Q-7**	**Q-8**
for δD and $\delta^{18}O$								
Development of meteoric water line for spring, rainfall etc.			♦	♦		♦	♦	
Establishment of altitude effect				♦	♦	♦		
Analysis of discharge data of spring and its relationship with isotope data				♦	♦	♦	♦	
Identification of recharge zones of springs						♦		
Formulation of strategies for development of spring sanctuaries						♦	♦	
Interim report				♦				
Draft report							♦	
Final report								♦

9. REFERENCE NUMBER: NIH/HID/INT/11-13/1

1	**Title of the study**	**:**	ASSESSMENT OF RADON CONCENTRATION IN WATERS AND IDENTIFICATION OF PALEO-GROUNDWATER IN PUNJAB STATE
2	**Name of PI, Co-PI, & their affiliations**	**:**	Mr. S. K. Verma Dr. Sudhir Kumar Dr. M. S. Rao Mr. Mohar Singh
3	**Type of study** (sponsored /consultancy /referred /internal). If referred, mention the reference	**:**	Internal
4	**Date of start, Scheduled date of completion**	**:**	April 2011 March 2013

5 **Location map (wherever applicable):**

Fig.: Map of Punjab State

6	**Study objectives**	**:**	To measure radon concentration in waters To identify paleo-groundwater in deep aquifers

7 **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 the Govt. 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.

8 Approved action plan : Please see Annexure 9.

9 **Timeline and justification for time over runs :** NA

10 **Objectives vis-à-vis achievements :**

S. No.	Objective	Achievement
1.	To measure radon concentration in waters	Radon concentration has been monitored at 21 sites located in three districts of Punjab during the field visit undertaken during Dec. 5-9, 2011. A field trip has also been planned during 3rd week of March 2012 to monitor radon concentration at more sites.
2.	To identify paleo-groundwater in deep aquifers	Sampling of groundwater for dating of water has been started and a total of 16 groundwater samples from shallow hand pump and tube wells have been collected for analysis for tritium dating.

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

12 Analysis and results :

The radon concentrations monitored in waters collected from different sources from th districts of Punjab are as detailed below:

Sr. No.	Name of District	Name of site/village	Source of water	Radon Conc. (Bq/litre)

1.	Ropar	1. Kharar	Hand pump	14.00
		2. Ropar Head works	Hand pump	12.00
		3. Ropar barrage	Satluj river	10.00
		4. Anandpur Sahib	Hand pump	20.00
2.	Nawanshahar	1. Rahon	Hand pump	28.00
		2. Urapar	Hand pump	20.00
		3. Jadala	Hand pump	24.00
		4. Balachaur	Hand pump	28.00
		5. Bhaddi	Tube well	24.00
		6. Ashron	Hand pump	38.00
		7. Allahchaur	Hand pump	30.00
		8. Banga	Hand pump	35.00
		9. Bisla	Hand pump	36.00
		10. Nawanshahar	Hand pump	40.00
3.	Hoshiarpur	1. Mahilpur	Hand pump	25.00
		2. Hoshiarpur	Hand pump	27.00
		3. Bhunga	Hand pump	38.00
		4. Dasuya	Hand pump	41.00
		5. Mukerian	Hand pump	48.00
		6. Sasan	Tube well	53.00
		7. Garhshankar	Hand pump	46.00

- It is revealed from above table that the radon concentration in water varies from 10 Bq/litre to 20 Bq/litre in district Ropar, from 20 Bq/litre to 40 Bq/litre in district Nawanshahar and from 25 Bq/l to 48 Bq/l in district Hoshiarpur. These values are under the max permissible limit recommended by WHO.

- In addition to above, a total of 16 ground water samples were collected from shallow hand pumps/tubewells from above mentioned sites. These samples have been enriched using Tritium Enrichment Unit and will be analysed for tritium using Quantulus available in Nuclear Hydrology laboratory.

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

15 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.

16 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 lab as well as in the field.

17	Data procured and/or generated during the study	:	NA
18	Study Benefits / Impact (2-column table showing achievements against measurable indicators as mentioned in the approved study document)	:	Data base on radon concentration in waters Information and data base about availability of paleo-waters in the study area.
19	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.
20	Shortcomings / difficulties, if any	:	NA
21	Future plan	:	As per activity chart

Annexure 9

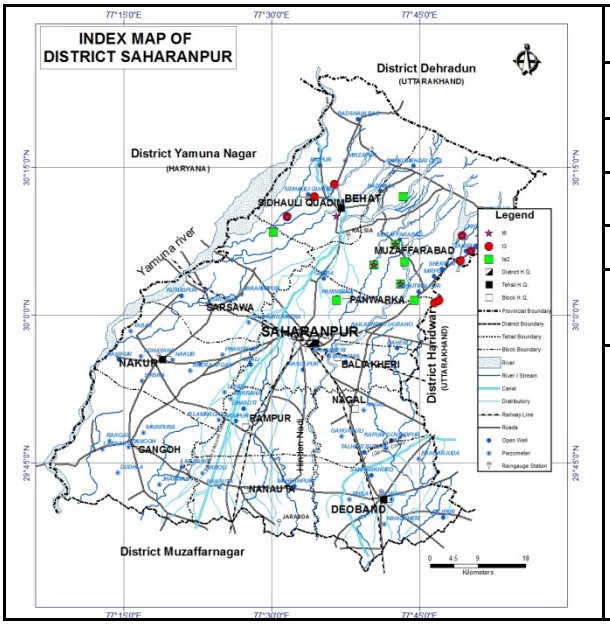
ACTIVITU SCHEDULE for ASSESSMENT OF RADON CONCENTRATION IN WATERS AND IDENTIFICATION OF PALEO-GROUNDWATER IN PUNJAB STATE

Sr. 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.	Lab. analysis of water samples for tritium dating			√	√	√			
5.	Collection of water samples for ^{14}C dating					√	√		
6.	Lab. 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								√

10. REFERENCE NUMBER: **NIH/HID/INT/11-13/2**

1 **Title of the study** **:** HYDROLOGICAL ASSESSMENT FOR ARTIFICIAL RECHARGE AND WATER MANAGEMENT IN GHAR AREA, SHARANPUR DISTRICT, U.P.

2	**Name of PI, Co-PI, &** their affiliations	**:**	Mr. Pankaj Garg (PI) Dr. Sudhir Kumar Dr. V. C. Goyal Dr. M. S. Rao Mr. C. P. Kumar Tanveer Ahmad Rajesh Agarwal
3	**Type of study** (sponsored/ consultancy/ referred/ internal). If referred, mention the reference	**:**	Internal
4	**Date of start, scheduled date of completion**	**:**	April 2011 - March 2013
5	**Location map** (wherever applicable)		



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

6	**Study objectives**	**:**	• To identify the groundwater recharge zones and groundwater flow velocity for Ghar area • To identify sites for water harvesting structures for Ghar area
7	**Statement of the problem**	**:**	Two blocks of district Saharanpur 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 these blocks which poses problem to

meet out the need of drinking water as well as water for irrigation. As per the 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.

8 **Approved action plan** : *Please see annexure 10.*

9 **Timeline and justification for time over runs** : NA

10 **2-column table showing objectives vis-à-vis achievements** (clearly separate achievements reported in the previous meetings) :

Objective	Achievement
• Review and synthesis of literature and purchase of map	• Literature survey completed.
• Data collection and preparation of index maps	• Required data collected and index map prepared.
• Analysis of water table data to identify water scarce zones, recharge areas and groundwater safe zones.	• On the basis of pre and post-monsoon G.W. table data (1998-09), water scarce zones, recharge areas and groundwater safe zones have been identified.
• Confirming the results using isotopic analysis of groundwater and using infiltration test	• Confirmation of results using isotopic, chemical analysis of groundwater and infiltration test is in progress.

11 **Recommendations/suggestions in previous meetings of Working Group/TAC/GB** : NIL

12. **Analysis and Results**

Water table details for the period 2000-2009 have been collected from 11 sites. Using the data, average depletion rate and average fluctuation in water table between pre and post monsoon for this period (2000- :

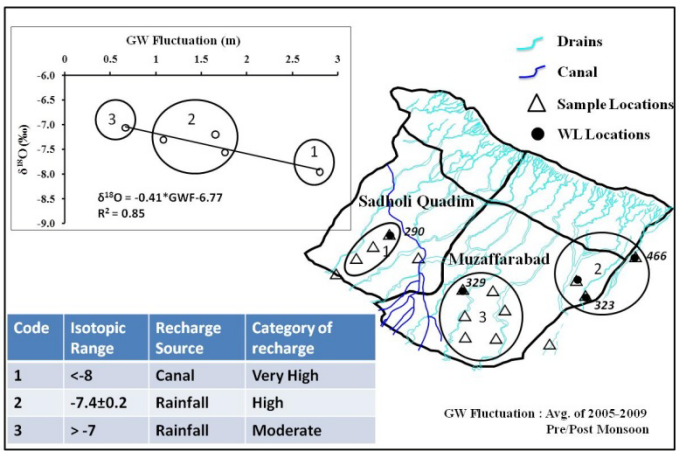
Site	Fall (-)/rise (+) in m per year	Category
Badshahibagh	+ 0.06	Safe

2009) is calculated. Depending upon rate of fall of water table and fluctuation before and after monsoon, the sites were categorized into safe to high risk locations and in low to high recharge sites respectively and are shown in the attached table. From the data, it can be seen that Badbala falls in high risk category and also it shows poor groundwater recharge. 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. Depending on the efficiency of surface soils for groundwater recharge low or high; deep well technique or surface recharge procedures can be adopted.

Samples were collected using public hand-pumps from sites where water table data was available. The samples were analyzed for isotopic details to identify sources of groundwater according to the stable isotopic composition and also relation between isotopic data and water table fluctuation is identified on the basis that at poor recharge area water remains on surface for longer duration leading to enrichment in its isotopic composition. The observed results are summarized in the figure. Further correlation of isotopic data with chemical data is in progress and will be presented during the Working

Shakumbari	0	(<0.1 m/yr)
Biharigarh	- 0.09	
Sherpur	- 0.23	Low risk (0.1 to 0.3 m/yr)
Meerpur	-0.24	
Mohand	-0.27	
Tanda MS	-0.44	Medium Risk (0.4 to 0.8 m/yr)
Sadoli Quadim	-0.5	
Raipur	-0.57	
Muzaffarabad	-1.01	High risk (>0.8 m/yr)
Badbala	-1.08	

Site	Water table Fluctuation	Category (Fluctuation)
Badbala	0.4	Low recharge (<0.5 m)
Meerpur	0.71	Moderate recharge (0.5 to 1 m)
Muzaffarabad	0.74	
Biharigarh	0.75	
Badshahibagh	0.79	
Sherpur	1.06	High recharge (1 to 2 m)
Tanda MS	1.3	
Mohand	1.4	
Shakumbari	1.79	
Sadoli Quadim	2.58	Very high recharge (> 2 m)
Raipur	4.3	



Group meeting.

13	**Adopters of the results of the study and their feedback**	**:**	1. UP State Ground Water Deptt., Saharanpur Division 2. CGWB, Regional Directorate, Lucknow 3. Local NGO's active in the study area 4. Local District Administration
14	**List of deliverables**	**:**	Reports and Papers
15	**Major items of equipment procured**	**:**	NIL
16	**Lab facilities used during the study**	**:**	Isotope lab., Hydrological Instrumentation lab., Remote Sensing lab.
17	**Data procured and/or generated during the study**	**:**	
18	**Study Benefits / Impact** (2-column table showing achievements against measurable indicators as mentioned in the approved study document)	**:**	i) Selection of study site – site has been selected ii) Collection of literature – some literature collected iii) Collection of water samples – 34 samples collected iv) Installation of Rain Gauge - Completed
19	**Specific linkages with Institutions and/or end-users/beneficiaries**	**:**	NIL
20	**Shortcomings/difficulties, if any**	**:**	NIL
21	**Future plan**	**:**	Identification of artificial recharge sites

Annexure 10

ACTIVITY SCHEDULE for HYDROLOGICAL ASSESSMENT FOR ARTIFICIAL RECHARGE AND WATER MANAGEMENT IN GHAR AREA, SAHARANPUR DISTRICT, U.P.

S.N.	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 test 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 zone)				√	√	√	√	
7.	Mass awareness program							√	
8.	Writing of report (Interim/Final)				√				√

PROPOSED WORK PROGRM FOR THE YEAR 2012-13

Besides the ongoing studies which would continue in the year 2012-13, following one new study is proposed in the work program of the Division for the year 2011-12.

NEW STUDIES

11. PROJECT REFERENCE CODE: NIH/HID/INT/12-14

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

Study Group: Dr. S. D. Khobragade
Mr. C. P. Kumar
Dr. Manohar Arora
Mr. A. R. Senthil Kumar

Type of Study Internal

Nature of Study Data generation and technology adaptation including promotion of citizen and state action for water conservation, augmentation and prevention: a goal under National Water Mission.

Duration: 2 Years

Date of Start: April 2012

Date of Completion March 2014

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

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

Study Area: Different climatic regions of India (about 4-6) depending upon the availability of data

Methodology:

In the proposed study, a simple climatic variability approach would be adopted to assess the sensitivity of evaporation to the possible rise in temperature using routinely observed minimum meteorological data. First, the major factors which are of importance in the process of evaporation and which are temperature dependent would be identified. Daily data of routinely observed meteorological parameters for different climatic regions of India would be used. Evaporation would be first estimated using the average values of the various meteorological data using modified Penman model. To evaluate the sensitivity of evaporation to rise in temperature, a hypothetical increase of 0.5, 1 and 2 ^{0}C in daily mean temperature would be assumed. The possible impact of the assumed increase in mean temperature on the various temperature depended parameters would be first studied using standard equations and ANN model. Then, using these changed values as input to the modified Penman model, future evaporation rates would be determined. The two evaporation rates would then be compared to analyze the variation in the projected estimates of evaporation. The variation in different climatic setting would be compared.

Action plan & time line:

S.N.	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 all 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**								√

Data requirement & Expected source:
Meteorological data such as maximum temperature, minimum temperature, wind velocity, sunshine hours, maximum relative humidity, minimum relative humidity, dry bulb temperature, wet bulb temperature, solar radiation etc are required. Most of the data would be purchased from IMD.

List of deliverables:
Projected rates of evaporation for different assumed rise of temperatures for different climatic regions of India

IPR potential and issues: NIL

Involvement of End Users/beneficiaries:
The beneficiaries of the study would be the water resource planners and managers of water resources of the study area in particular and India in general. However, the study does not need their direct involvement.

Specific linkages envisaged with Institutions and/or other NGOs: Sharing of data

Major items of equipment needed: None

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 E2
5	Dr A K Lohani	Scientist E2
6	Dr Senthil Kumar	Scientist E2
7	Dr Sanjay Kumar	Scientist E1
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 2011-12

Ref. Code	Study	Team	Duration
Internal Studies			
1. NIH/SWD/NIH/08-12	Study on integrated water resources management of sub-basin to cope with droughts	R.P. Pandey, Ravi V. Galkate, Surjeet Singh, L.N. Thakaral	4 years
2. NIH/SWD/NIH/09-12	Snow Melt Runoff Modelling in Sultej Basin	A.R. S. Kumar, Manohar Arora, A. Agarwal, D.S.Rathore, Digambar Singh	3 years
3. 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
4. NIH/SWD/NIH/08-	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora, Rakesh Kumar	To be continued
5. NIH/SWD/NIH/10-13	Climatic Scenarios Generation for Satluj Basin using Statistical Downscaling Techniques	Manohar Arora, Rakesh Kumar	3 years
6. NIH/SWD/NIH/09-11	Data book - hydro-meteorological observatory 2001-2008	Digambar Singh, A. R. S. kumar, Manohar Arora	2 years (up to Sept. 2011)
7. 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
8. 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
9. NIH/SWD/NIH/11-14	Hydrological Studies for Upper Narmada Basin.	Jagdish P. Patra, Rakesh Kumar, Pankaj Mani, T R Sapra	3 years

WORK PROGRAMME FOR THE YEAR 2012-2013

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/ 08-	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	March 08 -To be continued
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/ 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)
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)
Proposed new Internal studies			
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)
Consultancy Projects			
1.	Estimation of Design Basis - flood & safe grade elevation in the Upstream of Bargi Dam at Chutka Nuclear Power Project site, situated in Narmada Valley in Madhya Pradesh (NPCIL)	Rakesh Kumar Pankaj Mani J. P. Patra R. D. Singh T. R. Sapra N.K. Bhatnagar	Under Progress

2.	Site Specific Area Drainage Study for Plant and Ash Dyke for Khargone Super Thermal Power Project (2 x 660 MW) (NTPC)	Rakesh Kumar R.P. Pandey Pankaj Mani J. P. Patra R. D. Singh T. R. Sapra Om Prakash	Under Progress
3.	Area Drainage Study for Plant and Ash Dyke for Gajmara Super Thermal Power Project (4x800 MW)" (NTPC)	Rakesh Kumar Pankaj Mani J. P. Patra Archana Sarkar R. D. Singh T. R. Sapra Hukum Singh	Under Progress
4.	Drainage study for Rourkela Expansion Power Project (1*250 MW) (NTPC)	Rakesh Kumar Pankaj Mani J. P. Patra R. D. Singh A.R. Senthilkumar T. R. Sapra S.P.L. Shrivastava	Under Progress
5.	Carrying Out Dam Break Analysis and Preparation of Emergency Action Plan for Nagarjunasagar Dam	A.K. Lohani Rakesh Kumar S.K. Jain	Under Progress
6.	Study of hydro-meteorological droughts for Bundelkhand region in India	R.P Pandey M.K. Goel D.S. Rathore S.K.Singh	Under Progress

WORK PROGRAMME FOR THE YEAR 2011-12

1. PROJECT REFERENCE CODE: NIH/SWD/NIH/08-12

a) Title of study: **Study on Integrated Water Resources Management of Sub-Basin to Cope with Droughts**

b) Study group: R.P. Pandey, Sc. E2 & P.I., SWH Div.
Ravi V. Galkate, Sc. E1, RC Sagar
Surjeet Singh, Sc. E1, GW Div.
L.N. Thakaral, Sc. B, WRS Div.

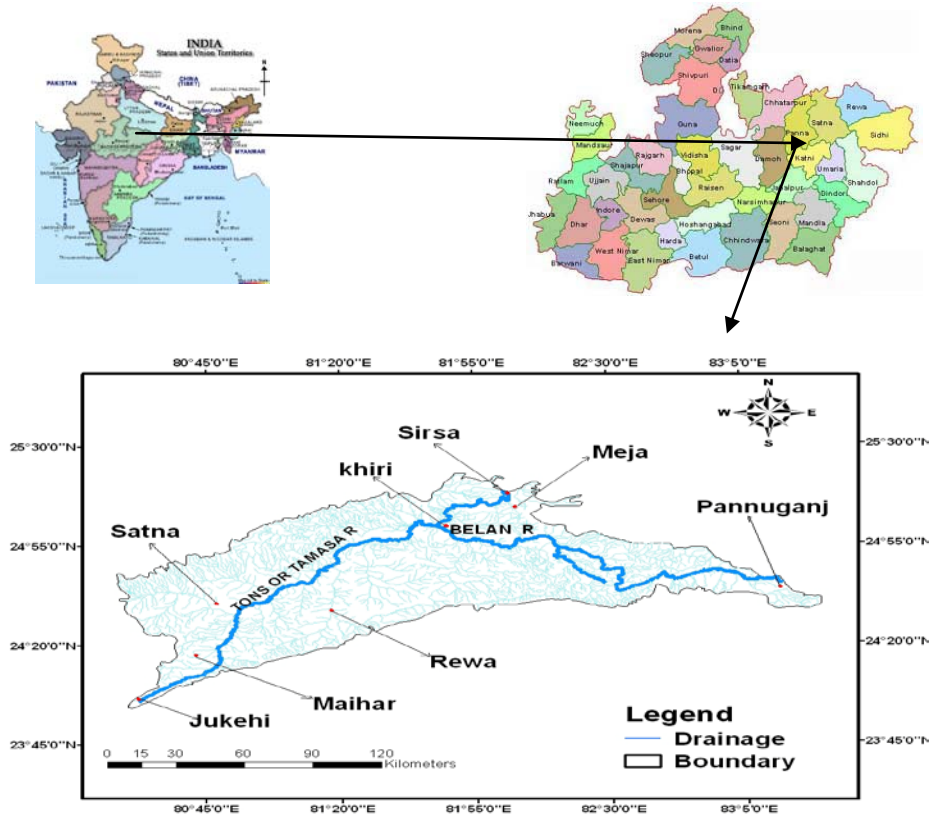
c) Type of study: Internal

d) Date of start: Dec. 2008

e) Scheduled date of completion: March 2012

f) Location map / study area:

Tons Basin



g) Objectives:

Major objective of the study is to devise an integrated water management plan for minimizing water stress during drought situation. The specific objectives of this project are to:

i. Developing inventory of drought events and water resources in study sub-basin.

ii. Identification of strategic surface and groundwater resources to be used in drought situations.
iii. Study of alternative means for minimizing adverse impacts of droughts.
iv. Characterization of drought based on hydro-meteorological, environmental, and socio-economic aspects in the selected basin(s).
v. Delineation of zones vulnerable to drought in the study sub-basin(s).
vi. Devise integrated water management plan to cope with drought.

h) Statement of the problem:

i. Area experiences recurrence of drought
ii. Unprecedented economic losses and great suffering to the affected areas.
iii. Reduced agricultural production and famine threat.
iv. Limited and scarce water resources and demand is very high for agriculture.
v. Year 2007 experienced the acute drought situation in this area.
vi. Limited and scarce water resources. Demand is increasing at a rapid rate due to demographic shifts and lifestyle changes.
vii. Area urgently needs attention and an integrated water resources management approach which includes drought management as a important component.

i) Approved action plan / Proposed work plan for the project:

- Reconnaissance survey, subsequent field visits and liasoning with the concerned departments/offices etc. in the proposed study areas.
- Procurement/Collection of maps and topo-sheets, long term hydro-meteorological and other relevant data/records.
- Digitization of maps, topo-sheets, preparation of maps of drainage, land-use, cropping system, DEM, water availability maps (SW & GW), irrigation maps etc. using GIS.
- Developing inventory of drought events, their impact and Identification of indigenous knowledge (ITKs) on drought mitigation in the study areas
- Analysis of meteorological, hydrological data and agricultural records for establishing regional drought indicators/indices.
- Classification of zones vulnerable to drought and water scarcity (preparation of vulnerability maps and their physical verification with ground truth).
- Random sampling and collection/investigation of socio-economic and environmental information.

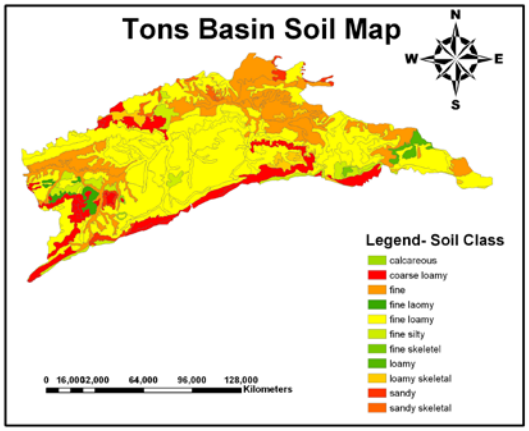
j) Objectives vis a vis Achievements:

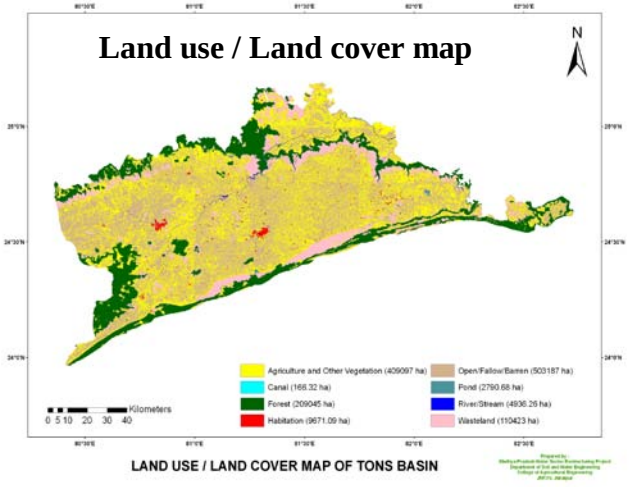
Objectives	Achivements
Field survey & data collection	Completed
Inventory of Water resources, drought events etc. in the study sites.	Completed
Preparation of base maps	Completed
Collection of rainfall data, and stream flow data from CWC	Completed
Rainfall Temperature, evaporation, Trend analysis	Completed
Analysis of dry spells & regional drought characteristics	Completed

k) Recommendations / suggestions in previous meetings of Working Group/TAC/GB

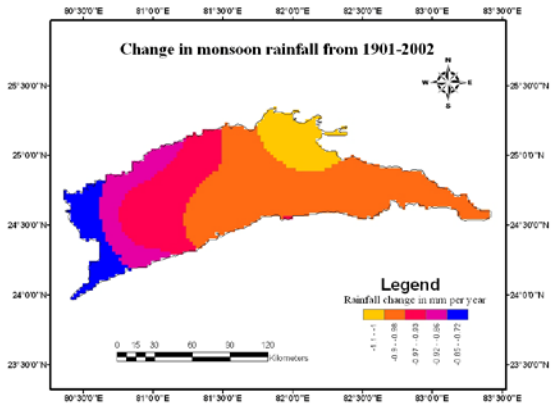
Nil

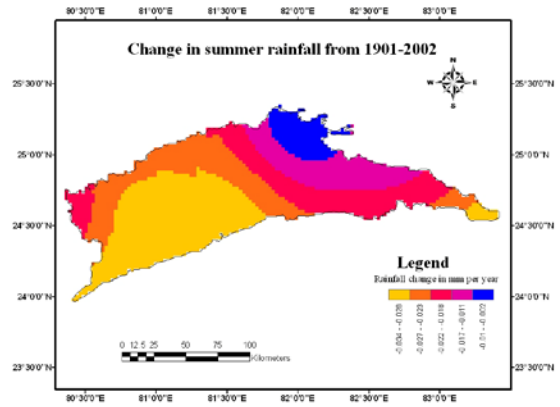
l) Analysis and results

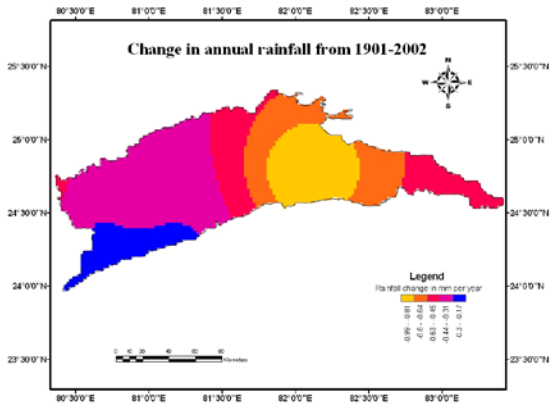


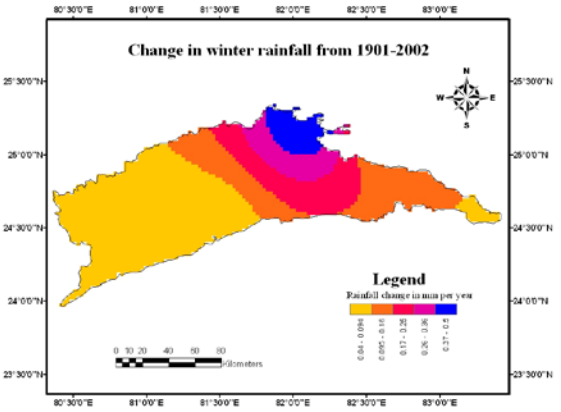


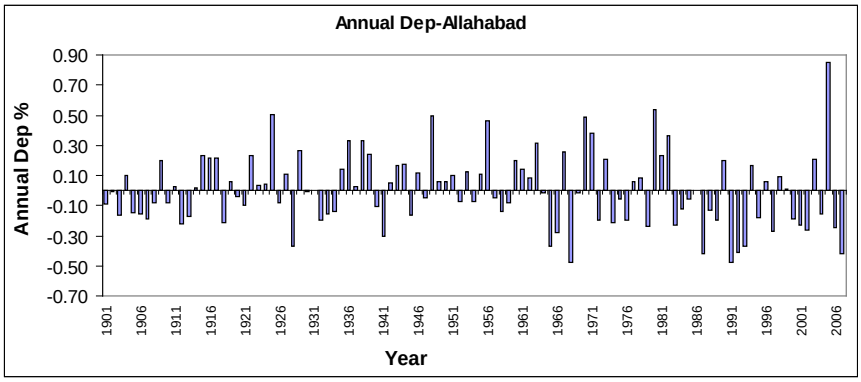
LAND USE / LAND COVER MAP OF TONS BASIN










Annual Dep-Allahabad
Annual Dep %
0.90
0.70
0.50
0.30
0.10
-0.10
-0.30
-0.50
-0.70
1901
1906
1911
1916
1921
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1931
1936
1941
1946
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1956
1961
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1971
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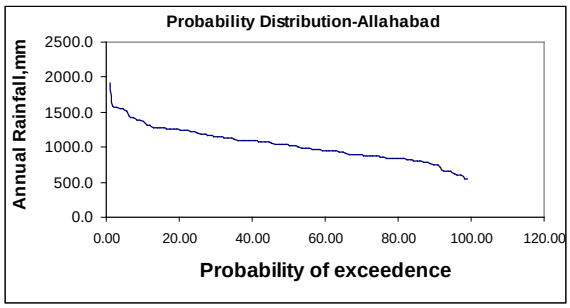
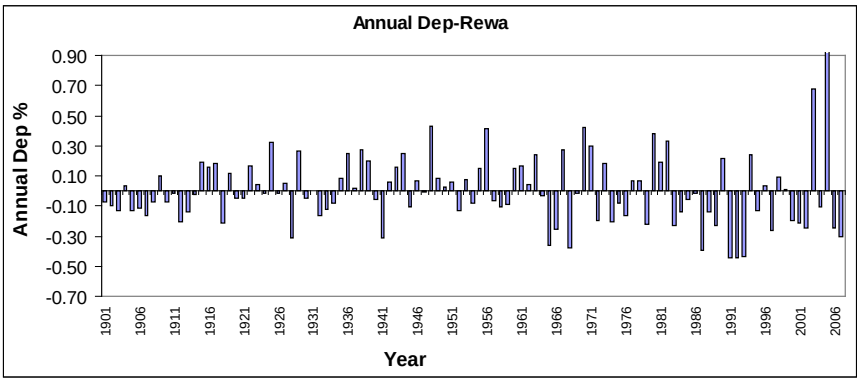
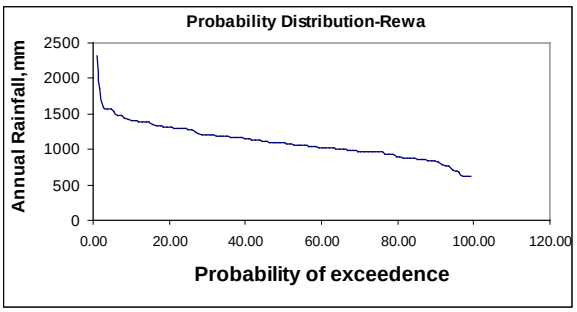
1991
1996
2001
2006
Year


Probability Distribution-Allahabad
Annual Rainfall,mm
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Probability of exceedence


Annual Dep-Rewa
Annual Dep %
0.90
0.70
0.50
0.30
0.10
-0.10
-0.30
-0.50
-0.70
1901
1906
1911
1916
1921
1926
1931
1936
1941
1946
1951
1956
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
Year


Probability Distribution-Rewa
Annual Rainfall,mm
2500
2000
1500
1000
500
0
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Probability of exceedence

Results of Mann Kendall test for temperature series
(A: annual, W: winter, S: summer, M: monsoon)

	Tmax				Tmin				Tmean			
	A	W	S	M	A	W	S	M	A	W	S	M
Allahabad	▲	▲	+	-	▲	▲	+	+	▲	▲	+	-
Katni	▲	▲	+	+	▲	▲	+	+	▲	▲	+	+
Rewa	▲	▲	+	-	▲	▲	+	-	▲	▲	+	-
Satna	▲	▲	+	-	▲	▲	+	-	▲	▲	+	-
Panna	▲	▲	+	+	▲	▲	+	+	▲	▲	+	+

▲&▲▲: Significant increasing at 5% &10%, ▼&▼▼: Significant decreasing at 5%&10%, +&-: non- significant increasing & decreasing trend.

m) Progress of work

Discharge data from CWC has been collected for two sites namely Meja-Road and Satna. Analysis of stream flow data is completed.

Data procurement from IMD is completed. Interim report progress of the study was submitted in April 2011. Required maps of the study area like drainage map, DEM, and soil map have been prepared. Inventory of problems in the study area has been prepared. Trend analysis of monthly, seasonal and annual rainfall has been carried out for basin. A visit for field investigations was taken up in Septrmbet 2011.

A summary of the analysis is as follows.

i. Area experiences recurrence of drought at an average frequency of once in 5 years.
ii. Water storages schemes in Nagod, Maihar and Rampur Blocks of the Satna district and Mauganj, Hanumana, and Sirmaur blochs of Rewa district are very few and the areas face frequent and unprecedented economic losses and great suffering due water stress during drought. Reduced agricultural production, mass migration and famine threat are major concern in these areas..
iii. Western part of the basin has observed falling trends of monsoon rainfall during past 102 years

iv. Limited and scarce water resources and demand is very high for agriculture.
v. Year 2007 experienced the acute drought situation in this area and caused 50-60% agricultural production losses.
vi. Limited and scarce water resources. Demand increasing at a rapid rate due to demographic shifts and lifestyle changes.
vii. Area needs attention and an integrated water resources management approach which includes drought management as an important component.
viii. Analysis work completed and final report writing is in progress.

n) List of deliverables:

i. Final report of the study is to be prepared by March 2012.
ii. This study presents detailed analysis of drought events suggesting a possible approach to deal with drought situation for minimizing crop losses and water stress in tons basin.
iii. A training course for one week duration was held on drought mitigation and management during October 31 –November 4, 2011.

o) Major items of equipment procured: Nil

p) Lab facilities during the study: Nil

q) Data procured / generated in the study: 10-daily Stream flow data for Tons River

r) Future plan of work under this project:

Analysis completed final report writing is in progress. Report will be submitted by mid-April 2012.

2. PROJECT REFERENCE CODE: NIH/SWD/NIH/09-12

a) Title of the study: **Snow Melt Runoff Modelling in Sultej Basin**

b) Study group: A. R. Senthil kumar Sc E1 & P.I., SWH Div.
Manohar Arora, Sc C & Co-P.I., SWH Div.
Avinash Agarwal, Sc F, SWH Div.
D. S. Rathore, Sc E2, WRS Div.
D. Singh, Sc B, SWH Div.

c) Type of study: Internal

d) Date of start: 1 April 2009

e) Scheduled date of completion: March 31, 2012

f) Location map / study area:

The catchment of Sutlej river up to Bhakra dam has been considered for the analysis. The catchment area up to Bhakra is 56,876 sq.km. The location of the study area is presented in Figure 1.

Fig. 1: Index map of Sutlej basin

For the development of the model, the daily rainfall values at Bhakra, Berthin, Rampur, Kalpa, Rakccham and Kaza, snowfall values at Rakccham and Kaza, mean temperature values at Rampur, Kalpa, Rakccham and Kaza, are available from 1987 to 2004. The discharge values at Bhakra dam for the same period are also available.

g) Objectives of the study:

(i) To simulate snow melt runoff using conceptual models SRM and SNOWMOD
(ii) To develop an ANN model to simulate the snow melt runoff
(iii)To compare the results of conceptual models with ANN model

h) Statement of the problem:

This study focuses on the development and evaluation of ANN models for the simulation of streamflow at Bhakra dam in Sutlej River and the results of ANN models are to be compared with the results of conceptual models such as SNOWMOD and SRM.

i) Approved action plan:

Year	April - June	July-Sept	Oct-Dec	Jan-March
2009-10	Literature review, Data collection and processing	Literature review, Data collection and processing, Development of ANN model for snow melt runoff considering the continuous data of streamflow	Development of ANN model for snow melt runoff considering the continuous data of streamflow, Development of ANN models for low, medium and high streamflow	Development of ANN models for low, medium and high streamflow
2010-11	Computation of snow covered area from satellite imageries	Computation of snow covered area from satellite imageries	Simulation of stream flow components by calibrating the parameters of SNOWMOD	Simulation of streamflow components by calibrating the parameters of SNOWMOD
2011-12	Simulation of streamflow by ANN model by considering the snow covered area, Simulation of streamflow components by calibrating the parameters of SRM	Simulation of streamflow by ANN model by considering the snow covered area, Simulation of streamflow components by calibrating the parameters of SRM	Simulation of streamflow components by calibrating the parameters of SRM, Comparison of the simulation results of stream flow by ANN, SNOW-MOD and SRM	Preparation of report

j) Objectives vis a vis achievements:

Objectives (for the period Sept. 2011-March 2012)	**Achievements**
1. Rerun of the ANN model with updated data	Completed
2. Comparison of results of ANN model with the results of SNOWMOD and SRM	Completed

k) Analysis and Results:

Brief methodology

SNOWMOD and SRM

SNOWMOD and SRM are conceptual models and the degree-day approach is adopted in the computation of snow melt runoff. The runoff contribution from snow covered area and snow free area are computed by standard formulae.

ANN Model

Three layered feed forward structure is selected for the ANN model. The training of the model is done by back propagation algorithm. The performance of the model is evaluated by coefficient of correlation, root mean squared error, model efficiency and percentage error in peak flow estimation.

Results

ANN model for simulating the streamflow at Bhakra Reservoir with updated data has been developed as per the suggestion of the working group members. The data from 01.01.1987 to 31.10.2002 are used for the calibration of the ANN model. The data from 01.11.2002 to 31.10.2004 are used for the validation of the models. The different combinations of rainfall, snowfall, mean temperature and discharge have been trained using the data and results are given in the following table. From the table, the model 1 is found to be the best model based on the performance indices during calibration as well as validation of the model.

Model No	Input combinations	ANN Structure	Calibration				Validation			
			CORR	EFF %	RMSE	Percent error in peak flow estimation %	CORR	EFF %	RMSE	Percent error in peak flow estimation %
1	$R_{bhak,t-1}$, $R_{ber,t-1}$, $R_{ram,t-1}$, $R_{kal,t-1}$, $R_{rak,t-1}$, $R_{kaz,t-2}$, $S_{rak,t-6}$, $S_{kaz,t-6}$, $TM_{ram,t-4}$, $TM_{kal,t-4}$, $TM_{rak,t-4}$, $TM_{kaz,t}$, $Q_{bhak,t-1}$	13-2-1	0.97	94.78	105.37	-21.83	0.97	94.48	83.10	-15.95
2	$TM_{ram,t-4}$, $TM_{kal,t-4}$, $TM_{rak,t-4}$, $TM_{kaz,t}$, $Q_{bhak,t-1}$	5-1-1	0.97	93.35	118.91	-42.21	0.97	94.38	83.92	-22.16
3	$TM_{ram,t-4}$, $TM_{kal,t-4}$, $TM_{rak,t-4}$, $TM_{kaz,t}$	4-5-1	0.86	74.17	234.27	-62.25	0.80	41.73	270.10	-33.19
4	$R_{bhak,t-1}$, $R_{ber,t-1}$, $R_{ram,t-1}$, $R_{kal,t-1}$, $R_{rak,t-1}$, $R_{kaz,t-2}$, $TM_{ram,t-4}$, $TM_{kal,t-4}$, $TM_{rak,t-4}$, $TM_{kaz,t}$, $Q_{bhak,t-1}$	11-9-1	0.98	95.99	92.26	-6.15	0.97	94.39	83.78	-28.38
5	$S_{rak,t-6}$, $S_{kaz,t-6}$, $TM_{ram,t-4}$, $TM_{kal,t-4}$, $TM_{rak,t-4}$, $TM_{kaz,t}$, $Q_{bhak,t-1}$	7-6-1	0.9	94.	108.64	-32.53	0.97	94.	83.51	-22.06

			7	4 5				4 3		
6	$R_{bhak,t-1}$, $R_{ber,t-1}$, $R_{ram,t-1}$, $R_{kal,t-1}$, $R_{rak,t-1}$, $R_{kaz,t-2}$, $S_{rak,t-6}$, $S_{kaz,t-6}$, $TM_{ram,t-4}$, $TM_{kal,t-4}$, $TM_{rak,t-4}$, $TM_{kaz,t}$	12- 5-1	0 . 9 1	8 1 . 9 4	19 5.9 0	- 25.70	0.8 2	4 7 . 5 4	25 6.2 8	-14.29

The stream flow at Bhakra reservoir have been simulated using the conceptual model SNOWMOD considering the snow cover area and other hydrological and meteorological parameters for the years 1999-2004. The data of November 1999 to October 2002 are considered for the calibration of parameters in SNOWMOD. The data of November 2002 to Ooctober 2004 are considered for the validation of the model.

The stream flow at Bhakra reservoir have been simulated using the conceptual model SRM considering the snow cover area and other hydrological and meteorological parameters for the years 1999-2004. The results obtained for SNOWMOD, SRM and ANN for various years are given below:

Year	Observed runoff Mm^3	SNOWMOD		SRM		ANN	
		Computed runoff Mm^3	R^2	Computed runoff Mm^3	R^2	Computed runoff Mm^3	R^2
1999-2000	12722.60	15528.24	0.81	9135.72	0.76	12799.22	0.94
2000-2001	10907.04	14580.74	0.85	9104.05	0.82	11349.51	0.96
2001-2002	13577.34	13735.33	0.70	12491.62	0.82	13818.39	0.96
2002-2003	14742.03	13102.90	0.79	13436.26	0.86	15003.88	0.95
2003-2004	8711.09	13092.44	0.81	8233.09	0.66	9193.95	0.91

The simulated annual runoff values by SNOWMOD are overestimated except for the year 2002-2003. The simulated annual runoff values by SRM are underestimated for all the years considered. But the simulated annual runoff values by ANN are very close to the observed runoff values. So it clearly indicates that the ANN model performed better than SNOWMOD and SRM in simulating the runoff values at Bhakra dam. This is represented by the following figure.

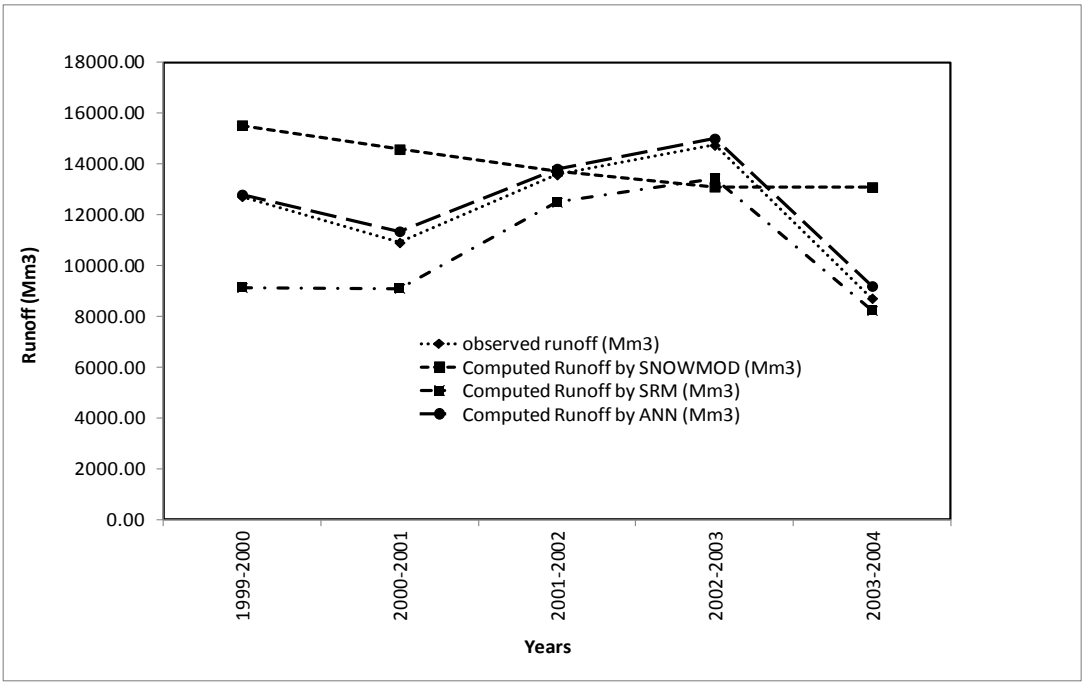


Fig 2. Comparison of the results of SMOWMOD, SRM and ANN

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

Water Regulation Division, BBMB, Nangal.

m) Data generated in the study:

The hydrological and meteorological data have been collected from the concerned divisions of BBMB, Nangal. The snow covered area for the different zones have been computed from the satellite imageries of different scenarios.

n) Study benefits/impacts:

The study suggests that ANN model is the best model for simulating the runoff at Bhakra Dam with the input data of rainfall, snowfall, mean temperature and streamflow at Bhakra reservoir.

3. 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:

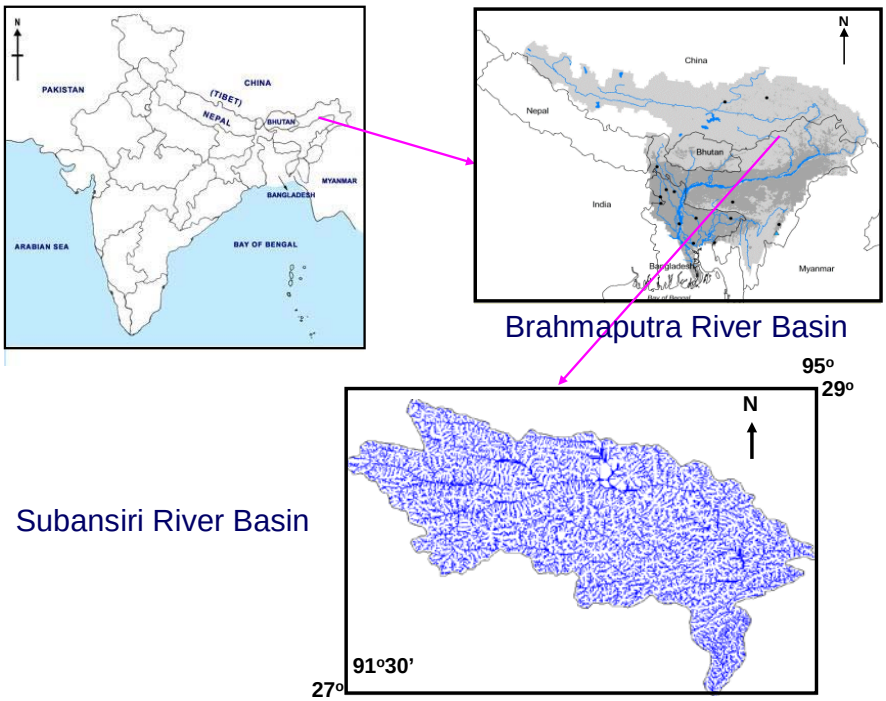


Fig. 1: Study Area

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. Literature collection for the technical report on "Snowmelt Runoff Modelling and Study of the Impact of Climate Change in part of Brahmaputra River basin"	Completed
2. Downloading MODerate resolution Image Spectral radiometer (MODIS) snowcover data products for part of Brahmaputra River Basin from the internet for the years 2000-2009.	Completed
3. Analysis and interpretation of weekly MODIS snowcover data collected for the period of 2000-2009 for part of Brahmaputra River Basin.	Completed
4. Preparation of technical report on "Snow Cover estimation and its temporal variation in a part of Brahmaputra River basin".	Completed
April 2011- Sept 2011	
1. Procurement and processing of daily Rainfall data	Completed
2. Procurement and processing of daily Temperature data	Completed
October 2011 – March 2012	
1. Test run of Snowmelt runoff model, SNOWMOD	Completed
2. To simulate stream flow for the study basin in present climatic conditions using long term records	In progress
3. Preparation of a technical report on "Snowmelt Runoff Modelling in a part of Brahmaputra River basin"	In progress

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

m) Analysis and Results:

Data Used

- Daily rainfall data at 0.5 deg grid from APHRODITE for whole of the Subansiri basin (Oct 2000- Sep 2005)
- Daily Temperature (Max and Min) data at one stations in Indian part of Subansiri basin (Oct 2000- Sep 2005)
- Daily SCA in all the elevation bands (Oct 2000- Sep 2005)
- Daily discharge at Choulduaghat site (Oct 2000- Sep 2005)

Results

The test run of SNOWMOD model has been taken for one year (2000-01) and the model parameters are being calibrated using long term data as above. The results would be presented during the working group meeting.

n) Expected adopters:

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

o) Deliverables:

Research paper would be prepared after completion of Part-II of the report.

p) Data procured and/generated during the study:

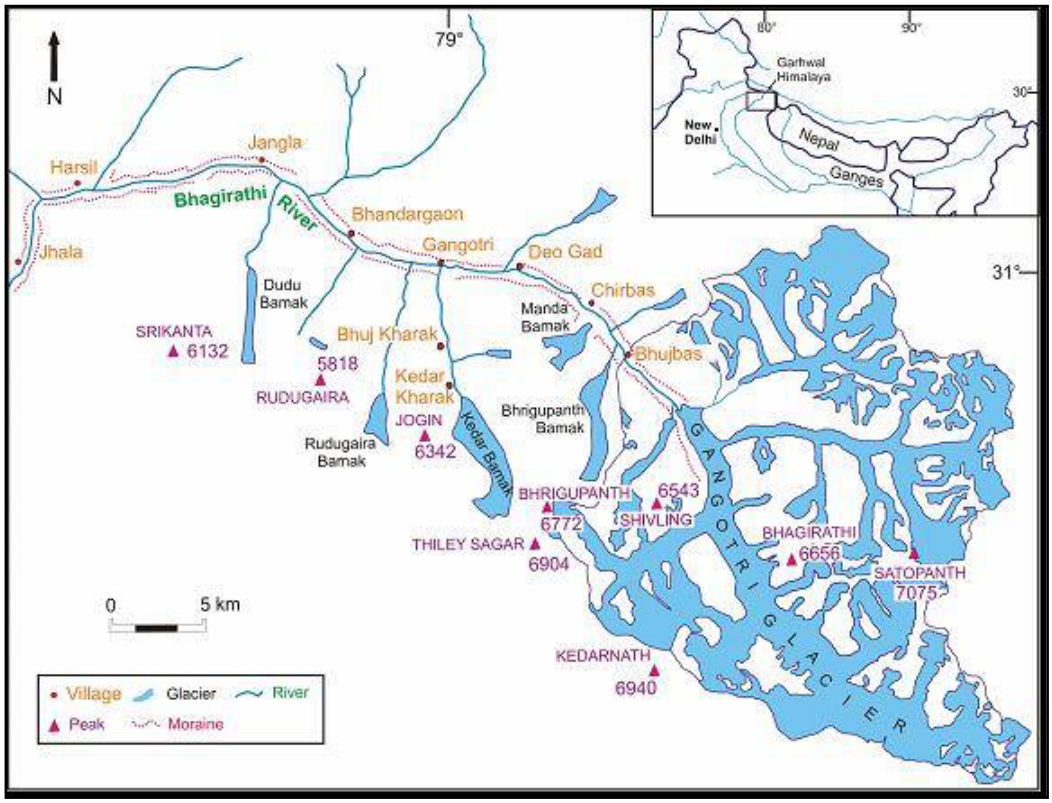
- MODerate resolution Image Spectral radiometer (MODIS) snowcover data products (MOD10A2 8-day composite) for Subansiri River Basin for the years 2000-2009.
- SRTM DEM
- Daily rainfall data at few raingauges in the Indian part of Subansiri basin (2000-07)
- Daily rainfall data at 0.5 deg grid from APHRODITE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

q) Future plan:

As per the approved action plan.

4. 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 2011 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 hydro meteorological data collected for the three ablation seasons during 2008 to 2010 was analysed and the draft report has been submitted. The summer data from May 2011 to October 2011 has been analysed. The data was collected for 143 days during ablation season 2011. The total rainfall was observed to be 264.1 mm. The mean monthy maximum and minimum temperatures were 14.3°C and 5.5°C respectively. The number of sunshine hours recorded daily was less in comparision to previous years i.e. 3.8 hours. The total volume of water received was 844 MCM which is below average than the 1000MCM average volume received and total suspended sediment load was 1.09×10^6 tonnes.

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 report for 2011 – 2014 will be prepared after completion of three years of investigations.
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.

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

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

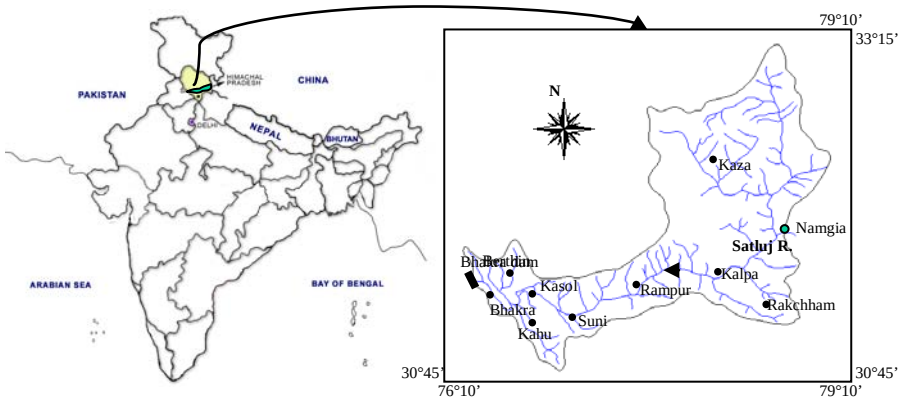
b) Study Group: Manohar Arora Sc 'C', SWH Div.
Rakesh Kumar Sc 'F', SWH Div.

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 NIES and NCEP Re-analysis data.

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 Processing	Downloading of GCM output	Preliminary processing of GCM
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 achievement:

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 required for the study has been obtained and the preliminary processing of the data has been carried out. The data has been downloaded and the procedure for AO quantitative evaluation has been finalized. After quantitative evaluation the future scenarios will be determined.

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.

6. PROJECT REFERENCE CODE: NIH/SWD/NIH/09-11

a) Title of the study: **Data Book- Hydro-Meteorological Observatory 2001-2008**

b) Study group: Digambar Singh, Sc B & P.I., SWH Div.
A. R. Senthil kumar Sc E1, SWH Div.
Manohar Arora, Sc C, SWH Div.

c) Type of study: Internal

d) Date of start: April 2009

e) Scheduled date of completion: Sep 2011

f) Location map / study area: NIH campus

g) Objectives of the study:

(i) To bring out the data book for NIH hydro meteorological observatory for the years 2001-2008

h) Statement of the problem:

The data of rainfall, relative humidity, maximum and minimum temperature, evaporation, and wind speed and wind direction have been collected since 1985. Initially, it is proposed to bring out a data book for the period from 2001to 2008 having the data in tabular form and with some basic statistics. The entry of the data is extended up to 2011.

i) Approved action plan

Year	April - June	July-Sept	Oct-Dec	Jan-March
2009-10	Entry of hourly rainfall data from hyetograph, Entry of hourly humidity data from hygrograph	Entry of hourly rainfall data from hyetograph, Entry of hourly humidity data from hygrograph	Entry of hourly rainfall data from hyetograph, Entry of hourly humidity data from hygrograph	Entry of hourly rainfall data from hyetograph, Entry of hourly humidity data from hygrograph
2010-11	Entry of hourly temperature from thermograph	Entry of hourly temperature from thermograph	Entry of evaporation, wind speed and wind direction	Entry of evaporation, wind speed and wind direction
2011-12	Entry of hourly rainfall, temperature and humidity data	Entry of hourly rainfall, temperature and humidity data	Analysis of the data	Writing of the report

j) Role and Responsibility of Team Members:

i. **Sh. Digambar Singh, Scientist B & PI**: Entry of data and processing, statistical analysis, report preparation and overall responsible for the study completion.
ii. **Dr. A. R. Senthil kumar, Scientist E1 & Co-PI:** Assisting in the entry and processing of the data and statistical analysis.
iii. **Dr. Manohar Arora, Scientist C & Co-PI:** Assisting in the entry and processing of the data and statistical analysis.

k) Objectives vis a vis Achievements

Objectives	Achievements
Entry of hourly rainfall data from hyetograph	Completed up to 2010
Entry of hourly humidity data from hygrograph	Completed up to 2010
Entry of hourly temperature from thermograph	Completed up to 2010

l) Analysis and Results

Brief methodology

Hydro-meteorological data is an initial and foremost requirement for the planning and execution of any water resources projects. National Institute of Hydrology commissioned a hydro-meteorological observatory in its campus in the year 1985. Observations of maximum temperature, minimum temperature, relative humidity, pan evaporation, rainfall, wind speed, wind direction are made on daily basis. The request for the data from other organizations is considerably more. So it is appropriate to bring out the data book in regular intervals. It is planned to enter the data in SWDES software and the related statistics of the data will be brought out in tabular forms.

Results

The hourly data of rainfall, relative humidity, temperature up to 2010 have been entered in SWDES. The data entry for 2011 is under progress. The basic statistics of the entered data will be computed after the completion of data entry.

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

Research students from IIT Roorkee, scientist from the Institute and filed engineers from state government departments.

n) Deliverables: A report containing data in tabular form with basic statistics.

o) Data generated in the study: Data in tabular form with basic statistics.

p) Study benefits/impacts: The compiled data may be used for field and research purposes

7. 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.

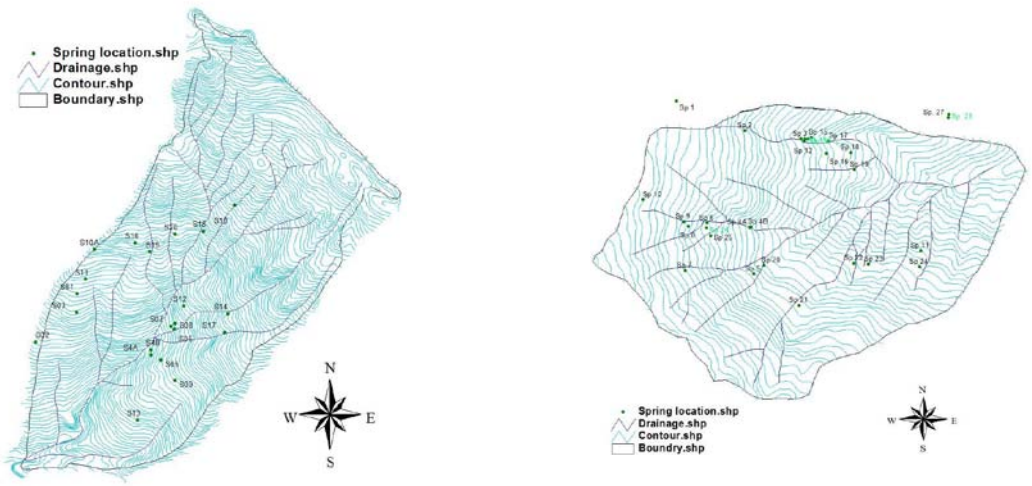


Figure 1: Chandrabhaga and Danda watersheds and location of springs.

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:

A net work of instrumentation of previous project is continued as a pilot monitoring system in middle Himalayan region (Uttarakhand). This net work of instrumentation and data collected will be used to obtain the objective of the project. The monitoring continued for watersheds (Chandrabhaga, Danda) for 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). Spring flow around twenty locations in each watershed.

i) Approved action plan:

Year	1st quarter (A M J))	2nd quarter (J A S)	3rd quarter (O N D)	4th quarter (J F M)
2010			Maintenance and up keeping of installed equipments	Processing and analysis of data collected during 2010
2011	Interactive workshop	Literature review and development of model	Interpretation of results	Processing and analysis of data collected during 2011
2012	Development of appropriate model	Interactive workshop	Interpretation of results	Processing and analysis of data collected during 2012 Interactive workshop
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. Development of implementable technology for water availability analysis (analysis and model development). Presentation of progress 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 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:

Working group suggested that the objectives must reflect the climatic variability analysis and its impact. The objectives have been modified as:	
Old objectives	New objectives
▪ Detailed hydrological monitoring, collection of data at watershed scale and creation of a centralized database for watershed for the benefit of the users. ▪ Development of implementable technology for water availability analysis. ▪ Interaction and transfer of developed implementable technology to users.	▪ Development of rainfall-runoff, rainfall-spring flow relationships and assessment of climatic variability. ▪ Estimation of impact of climatic variability on runoff and spring flow. ▪ Detailed hydrological monitoring, collection of data at watershed scale and creation of a centralized database for watershed for the benefit of the users. ▪ Development of implementable technology for water availability and transfer of developed technology to users.

l) Achievements:

i. Maintenance and up keeping of installed equipments.
ii. The collected data has been processed for daily and the record has been updated.
iii. Spring flow data has been analyzed for its lag with rainfall on daily and monthly basis and for spring flow variability.

m) Results in brief:

- **Maintenance and up keeping of installed equipments.**
- **Spring Flow analysis.**
- Cumulative rainfall and spring flow indicated a high correlation for all springs under observation in both the watersheds. Rain to spring lag on daily and monthly basis resulted a lag of 9 to 30 days and on monthly basis as zero to one month for Chandrabhaga springs. Springs of Danda indicated a lag of 1 to 29 days and on monthly basis as zero to two months.
- Measured springs of the watersheds have been classified in to three groups (perennial, non-perennial and dead springs) based on the flow availability and the record through out years. The springs with continuous availability of water were considered as perennial, the springs with one or more nil flow periods in a year as non-perennial and springs never regained after a specific time as dead.

- **Processing and analysis of data collected up to Sept. 2011.**

The data collected till Sept. 2011 has been processed for daily and the record has been updated.

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

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.

8. 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) 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.

The Teesta River is then fed by rivulets which arise in the Thangu, Yumthang and Donkia-La ranges. The river then flows past the town of Rangpo where it forms the border between Sikkim and West Bengal up to Teesta Bazaar. The Teesta River has preserved good imprints of climatic and tectonics along its valleys and catchments. There

are a number of glaciers are present in the Teesta basin. This covers an area of 440.300 sq.km. A number of hydropower projects are proposed within the Teesta river basin. It is estimated that it would produce some 50,000 MW of electricity within the next 10 years. Keeping in view the ongoing development activities in the Tista basin, preparation of inventory of glaciers and glacial lakes, glacial lake outburst flood study are very much important for flood estimation and management.

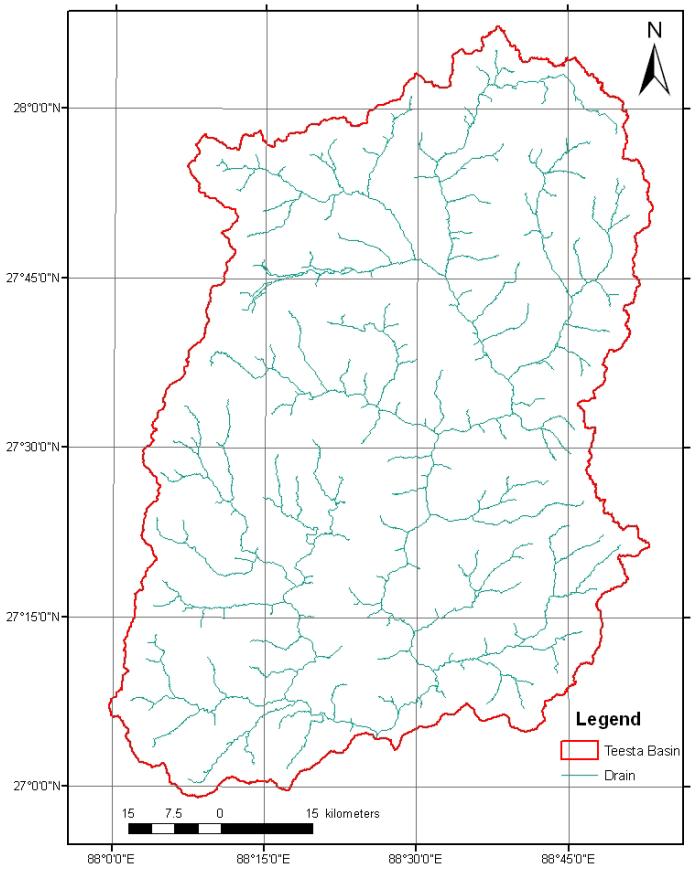


Fig. 1: Basin map of the study area

h) 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.

i) Role and Responsibility of Team Members:

Dr. A.K. Lohani, Scientist 'E2': Data Collection, Data Processing, Simulation of glacial lake outburst using MIKE 11

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

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

j) Approved action plan :

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

k) Achievements

Year	Objectives (for the period April 2011 to September 2011)	Achievements
October, 2011 to March 2012	1. Creation of Basin map 2. Creation of data base in GIS 3. Classification of data for lake inventory 4. Identification of glaciers and lakes 5. Methodology for GLOF	Completed In progress In progress In progress Finalized

l) Recommendation / suggestions in previous meetings of Working group / 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.

n) Deliverables:

Reports and research papers

o) Data generated in the study:

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

9. 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 'E1', 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:

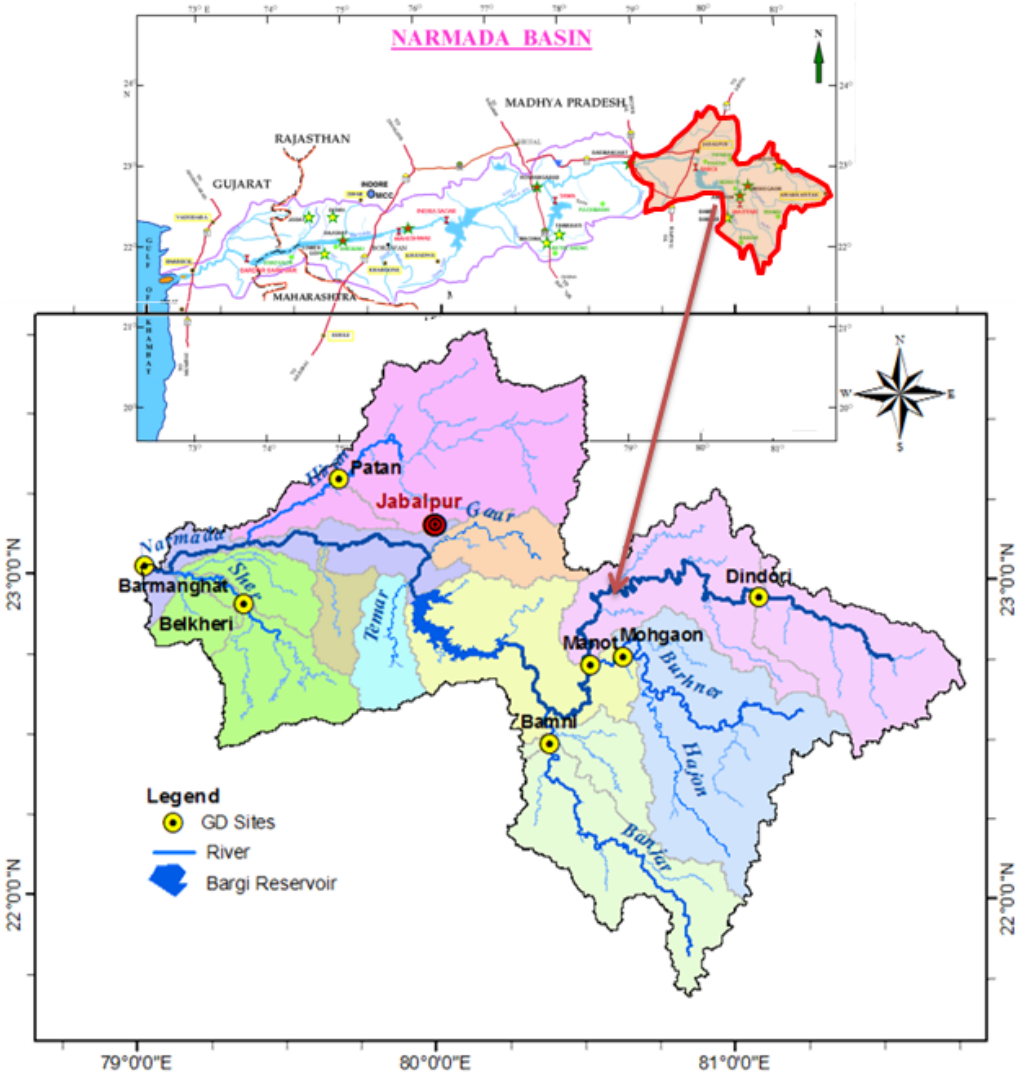


Fig. 1: Location map of study area.

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 km² 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							Under Progress
Processing and analysis of data							Under Progress
Modelling work							Under Progress
Reporting / Assessment of 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 dam. Dam break analysis of Bargi dam for various failure scenarios will be simulated using MIKE Flood and flood propagation along 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 main focus was on data collection and literature survey as mentioned in the approved action plan. Various previous studies on Narmada basin at NIH are referred along with other published literatures. Rainfall data at six raingauge stations are collected from IMD, Pune. Further stage-discharge and river cross-section are collected from CWC. However, some missing values are there in the series and we are planning to collect some addition data and if possible increase the length of time series in future. Reservoir characteristics curve, design dimension, inflow, release etc. are obtained from office of Chief Engineer (Bargi), Rani Avantibai Pariyojana, NVDA, Jabalpur (MP).

DEM of the study are is prepared from SRTM data and used to delineate sub basins using HEC-GeoHMS. The basin upto bargi dam is divided into 5 sub basins as shown in Fig. 2. The basin characteristics required for generating synthetic unit hydrograph using CWC method is also estimated (Table 1).

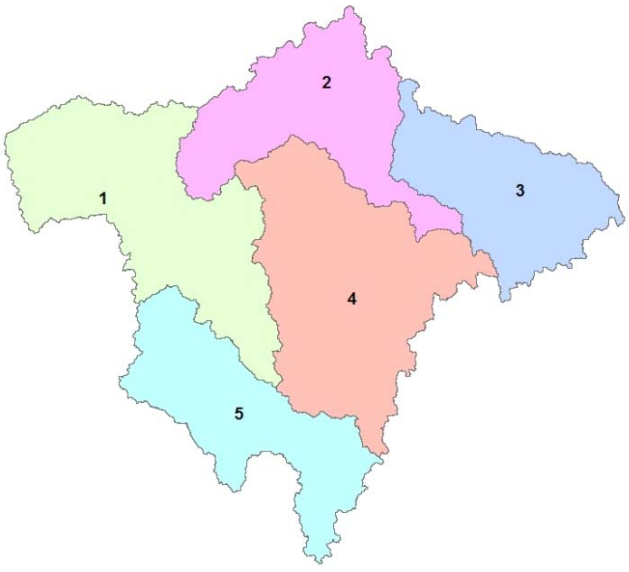


Fig. 2: Delineated sub basins.

Table 1: Basin characteristics

Basin No	A	L	L_C	S
1	3596.30	170.72	66.86	2.53
2	2612.27	206.88	97.65	2.59
3	2311.98	111.00	55.47	2.77
4	3978.36	173.33	88.83	2.59
5	2533.82	172.60	91.52	1.47

Synthetic Unit Hydrographs

Using the relationships derived in CWC report the SUH parameters are estimated from basin characteristics. The SUH developed using these parameters for delineated five sub basins are shown in Fig. 3.

Estimation of design rainfall

The design 1-day maximum rainfall for 50 and 100 year return periods are taken from the CWC report. Further, design storm duration of each sub basin is estimated and the time distribution of rainfall is made according to CWC report as shown in Fig 4.

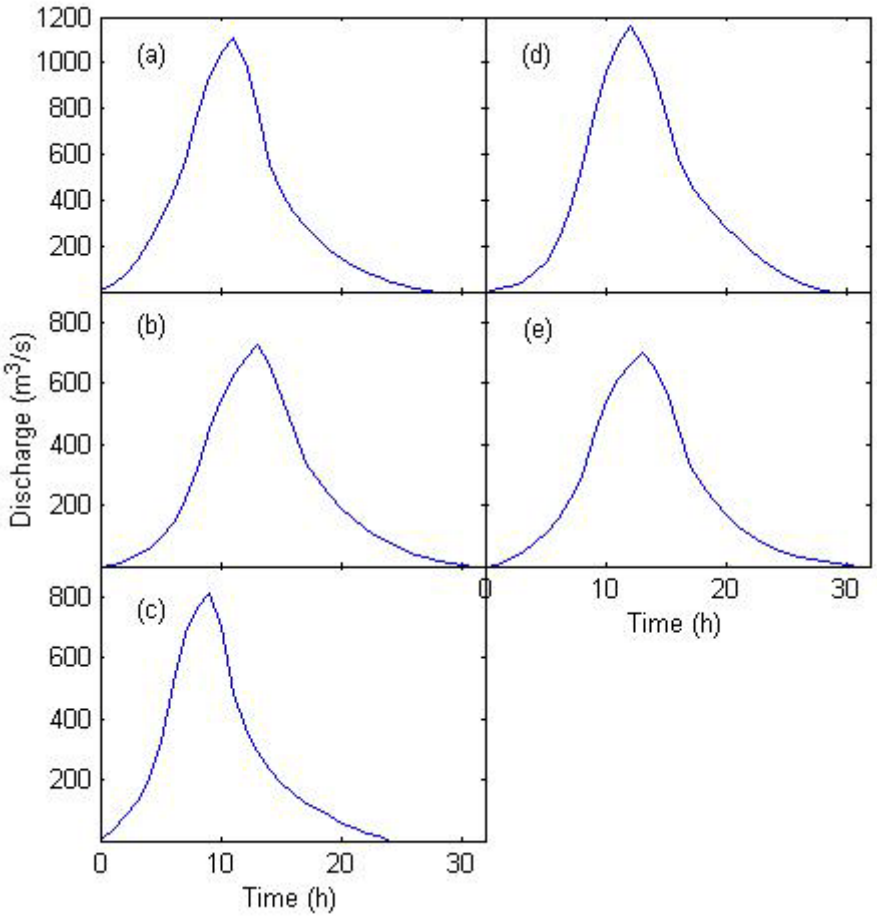


Fig. 3: Estimated SUH for five sub basins.

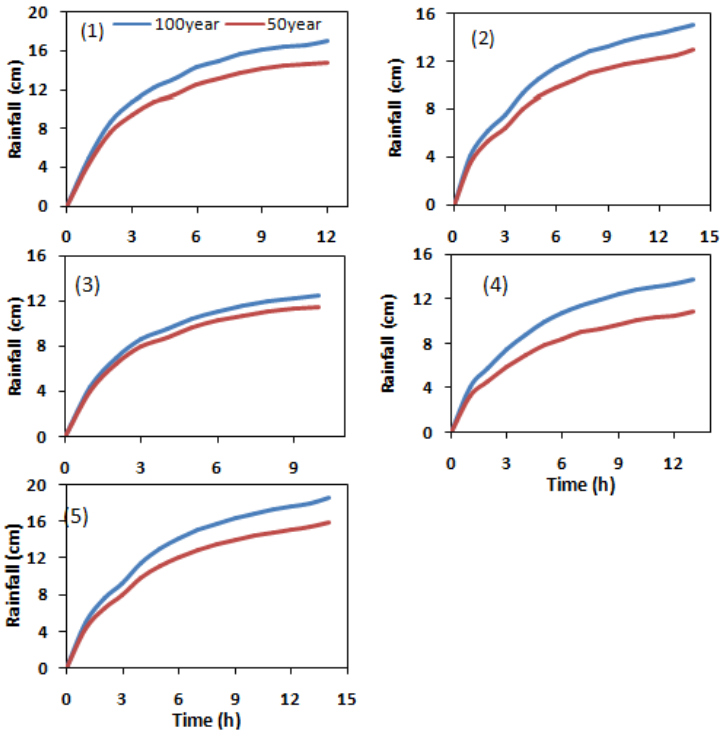


Fig. 4: Time distribution curve of design storm.

Design flood hydrographs

Design loss rate of 0.10 cm/hr is used to obtain effective hourly rainfall. The effective rainfall and constant base flow for each sub basin is provided as input to the HEC-HMS basin model (Fig. 5) to estimate discharge at Bargi dam (junction 3). However, the model has not been calibrated yet. The preliminary result shows the peak flow to Bargi dam is 38,012.2 m^3/s and 45,004.7 m^3/s for 50 and 100 year return period respectively. The flood hydrographs are shown in Fig. 6.

Fig. 5: Basin Model setup in HEC-HMS.

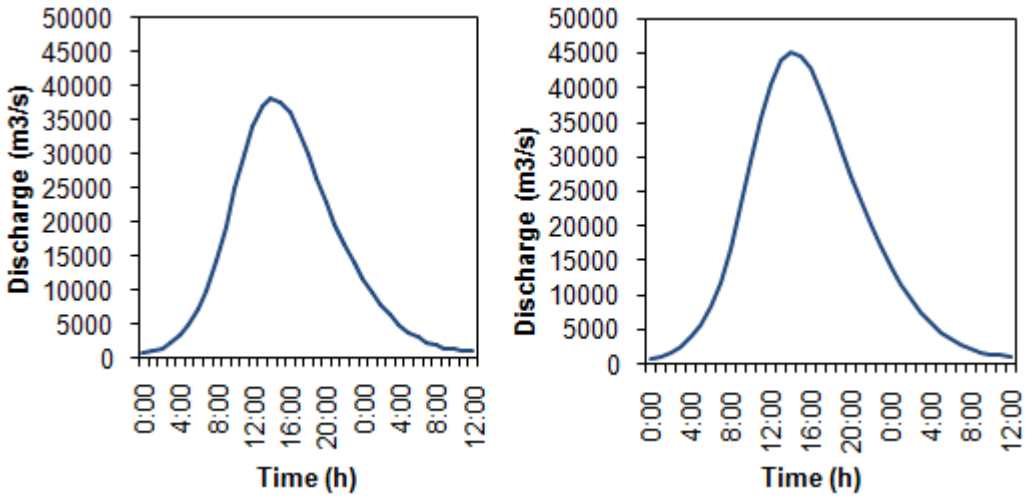


Fig. 6. Design flood hydrographs at Bargi dam for 50 and 100 year return period.

Further, the floods for various return periods are estimated by regional flood frequency relationships are developed based on the L-moments approach for Upper Narmada and Tapi Subzone 3(c). The values of floods of various return periods for ungauged catchments of the study area may be estimated using the following equation, which has been developed by coupling the regional flood frequency relationship of estimation of floods of various return periods for gauged catchments with the regional relationship between mean annual peak flood and catchment area.

$$Q_T = C_T (A)^{0.58} \quad (19)$$

Where, Q_T is the flood estimate for T year return period, C_T is the regional coefficient for T year return period (Table 2) and A is the area of ungauged catchment.

Table 2 Values 'C_T' for Subzone 3(c)

Return periods	**2**	**10**	**25**	**50**	**100**	**200**	**500**	**1000**
C_T	15.36	26.89	44.50	51.65	58.65	65.54	74.50	81.19

m) Action taken on comments of previous working group meeting

Sl No	Comment/Suggestion	Action taken
1	To use runoff-volume models in HEC-HMS	Presently, the hourly rainfall data is not available with us. We have collected hourly stage data and we will have to collect some hourly rainfall data for rainfall-runoff modelling in HEC-HMS
2	Validation of flood inundation maps with remote sensing images	This aspect will be taken care.

n) List of deliverables:

Papers and reports.

o) Data collected/generated:

- DEM of the study area is generated from SRTM.
- Land use and land cover map is generated by classifying LANDSAT image.
- Daily 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.
- 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).

o) 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.

NEW STUDIES PROPOSED FOR 2012-13

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

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

b) Study group: R.P.Pandey**,** Sc E2 & 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: Ken and Betwa Basin in Bundelkhand

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 in space and tine.
(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 Bundelkhand,

h) Statement of the problems of the study area:

(i) Bundelkhand region faces recurrence of droughts of greater severity.
(ii) Frequent failures of crops are reported in Bundelkhand due to drought.
(iii) Larger part of Bundelkhand do not have reliable sources of drinking water supply. There are scarcity of sustained water resources in the region to meet water demand during summer season. demand is very high for agriculture.
(iv) In recent past during 2004- 2008, it experienced the acute drought situation and water scarcity.
(v) Area needs attention for integrated water resources management.

i) Proposed methodology:

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

- Field investigations and data/information collection from various sources in the proposed study areas.
- Procurement/Collection of long term hydro-meteorological and other relevant data/records.
- Preparation of base maps of drainage, land-use, cropping system, DEM, water availability maps (SW & GW), irrigation maps etc. using GIS.
- Inventory of past drought events, their impact and identification of indigenous knowledge (ITKs) on drought mitigation in the study areas
- Analysis of meteorological, hydrological data and agricultural records for establishing regional drought indicators/indices.
- Classification of zones vulnerable to drought and water scarcity (preparation of vulnerability maps and their physical verification with ground truth).
- Assessment of surface water (Streanflow & Storages) and groundwater availability, (recharge/aquifer storages) at monthly time step.
- Assessment of water demand for domestic, industry and agriculture at monthly time step.
- Assessment of life saving supplemental irrigation requirement for crops to meet dryspell demand.
- Preparation of suitable plan for water resources augumentation and storages.

j) 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

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

(i) Final report of the study is to be prepared by March 2015.
(ii) This study will yield suitable approach to quantify drought attributes, area specific water availability, demand and magnitude of deficit in the Bundelkhand.
(iii) 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.

2. 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

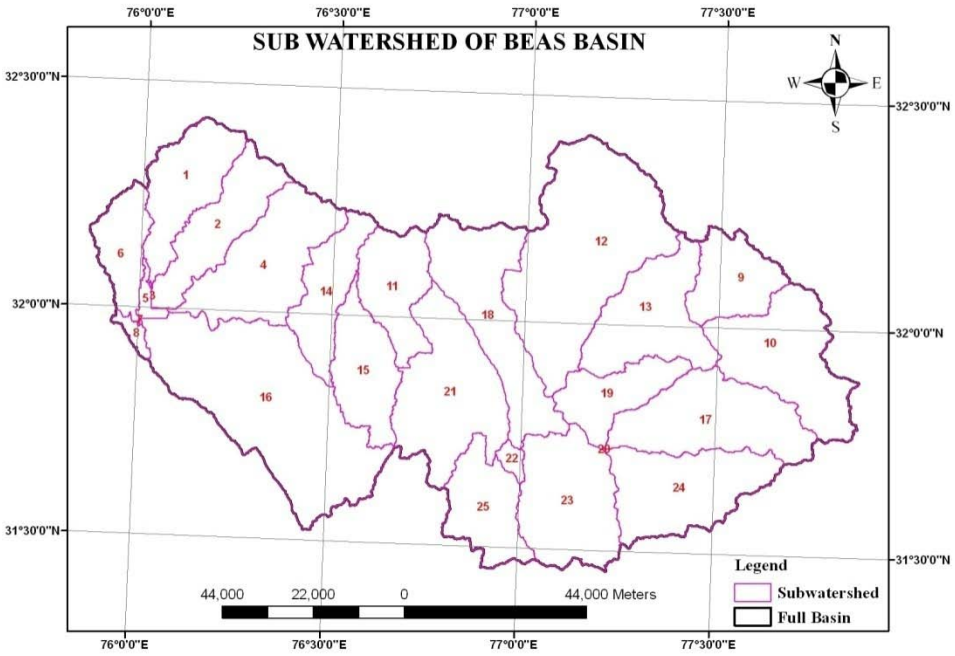
d) Date of start: 1 April 2012

e) Scheduled date of completion: March 31, 2015

f) Nature of study: Technique development

g) Location map / study area:

Pong Dam is located on the Beas River, which is one of the five major rivers of the Indus basin. The river Beas flows from the Beas Kund near Rohtang Pass in the upper Himalayas and traverses a total length of about 116 km from the source to the Pong Dam. The reservoir drains a catchment area of 12,562 km^2 out of which the permanent snow catchment is 780 km^2. The study area is given as follows:



Monsoon rainfall between July and September is a major source of water supply to the reservoir, apart from snow and glacier melt. The dam acts as a sponge for flood flows, and reservoir regulation prevents the inundation of surrounding upland areas from routine flooding during the monsoon season. The reservoir stretch is 42 km long with a maximum width of 19 km, and with a mean depth of 35.7 m. The designed maximum flood discharge of (12,400 m^3/s is discharged through a gated chute spillway located on the left abutment of the dam. The Beas river along with its tributaries generate lot of sediments while flowing through hilly regions and transports the sediment into the Pong reservoir.

h) 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

i) Statement of the problem:

The upstream activities of the catchment induce higher sediment load in Beas river and it affects the designed life of the reservoir Pong. This study will focus on the development of technique to assess future sediment rates and the life of the Pong reservoir which will help reservoir authorities in planning for irrigation, water supply, flood control and hydro power generation.

j) End users/ beneficiaries of the study:

Bhakra Beas Management Board in particular and people at large in general.

k) Methodology:

Sediment yield model

Multiple Linear regression (MLR) and ANN models would be 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 would be 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 would be applied to compute the sediment volume for future 25, 50, 75 and 100 years. The unit weight of deposited sediment in the reservoir would be 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 would be arrived at by empirical equation as well as statistical methods. The consolidated unit weights computed by

different methods would be 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 would be distributed in the reservoir by empirical area reduction method.

l) Action plan and timeline:

Year	April – June	July-Sept	Oct-Dec	Jan-March
2012-13	Literature review, Data collection and compilation	Literature review, Data collection, compilation and processing,	Development of sediment yield model	Development of sediment yield model
2013-14	Generation of rainfall and runoff series for future periods	Computation of sediment yield based on rainfall and runoff series for future periods	Computation of consolidated sediment volume for future periods	Computation of consolidated sediment volume for future periods
2014-15	Assessment of life of the reservoir	Revision of elevation-area-capacity table of the reservoir	Revision of elevation-area-capacity table of the reservoir	Preparation of report

m) Data requirements:

i) Existing elevation-area-capacity table of the reservoir
ii) Suspended sediment concentration
iii) Historical Rainfall data for the upstream stations
iv) Historical Runoff series at the entry of the reservoir
v) Hydrographic survey data

n) Delivarables:

i) Sediment yield model
ii) Revised elevation area capacity curve
iii) Future rainfall series
iv) Future runoff series
v) Life of reservoir
vi) Comprehensive report giving data, maps and results
vii) Research papers

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

Bhakra Beas Management Board.

WATER RESOURCES SYSTEM DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr S K Singh	Scientist F & Head
2	Mrs Deepa Chalisgaonkar	Scientist F
3	Dr Sanjay K Jain	Scientist F
4	Dr M K Goel	Scientist F
5	Sri D S Rathore	Scientist E2
6	Dr P K Bhunya	Scientist E1
7	Dr (Mrs) Rama Mehta	Scientist C
8	Sri L N Thakural	Scientist B
7	Sri Tanvear Ahmed	PRA
8	Sri P K Agarwal	PRA
9	Sri Yatvear Singh	SRA
10	Mrs Anju Chowdhary	SRA

WORK PROGRAMME FOR THE YEAR 2011-2012

S.N.	Study	Team	Duration
Internal Studies			
1.	Application of a distributed hydrological model for river basin planning and management	M.K. Goel, Vijay Kumar, D.S. Rathore, D. Chalisgaonkar, Rama Mehta	2 yr 6 month (10/09-3/12)
2.	Web based Information System for Major and important Lakes in India	D. Chalisgaonkar, Suhas Khobragade	1 year (4/10-3/12)
3.	Analysis of water management scenarios in Tapi River basin using MIKE Basin	Rama Mehta (PI), M.K. Goel, Vijay Kumar/D.S. Rathore	3 years (4/10-3/13)
4.	Development of analytical equation for alternate depths for flow in rectangular channels	S.K. Singh	1 year (4/11-3/12)
5.	A transfer function model for event based runoff	S.K. Singh	1 year (4/11-3/12)
6.	Trend and variability analysis of Rainfall and Temperature in Himalayan region	L.N. Thakural, Sanjay Kumar, Sanjay Kumar Jain, Tanveer Ahmad	3 years (10/11-9/14) **New Study**
Sponsored Projects			
7.	Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin	Sanjay K. Jain, Bhishm Kumar, Vijay Kumar, S.P. Rai, Renoj Theyyan	3 Years (4/09 – 3/12)
8.	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, D.S Rathore, L.N. Thakural, Rama Mehta	3 Years (4/09-3/12)
9.	Hydrological Assessment of Ungauged Catchments (Small Catchment)	P.K.Bhunya (PI), Rakesh Kumar, D.S. Rathore, Sanjay Kumar, P.C. Nayak	2 Years (5/09-5/12)
Consultancy Projects			
10.	Vetting of Water Availability studies of the Gulf of Khambhat Development Projects (Kalpasar Project)	M.K. Goel Vijay Kumar	6 Months (4/10-12/11)
11.	Glacier Lake Outburst Flood (GLOF) study for Jelam tamak (THDC India Ltd.)	Sanjay K Jain, AK Lohani, L N Thakural, Anju Chaudhary, Tanvear Ahamd	
12	Snowline estimation, snowmelt runoff study and Glacial Lake Outburst Flood study for Chamkharchhu H.E. Project in Bhutan (NHPC, Faridabad)	Sanjay K Jain, A. K. Lohani, L. N. Thakural, Anju Chaudhary	
13	Snowline estimation snowmelt runoff study and Glacial Lake Outburst Flood study for Kuri-Gongri H.E. Project in Bhutan (NHPC, Faridabad	Sanjay K Jain, A K Lohani, Sudhir Kumar, L N Thakural, Anju Chaudhary, Tanvear Ahamd, PRA	

WORK PROGRAMME FOR THE YEAR 2012-2013

Progress of Work Programme for the year 2011-12

1. Application of a distributed hydrological model for river basin planning and management (Research study)

Study Group	Scientists: M. K. Goel, Scientist F D. S. Rathore, Scientist E2 Deepa Chalisgaonkar, Scientist F Rama Mehta, Scientist C Scientific staff: Tanveer Ahmad, P.R.A. P. K. Agarwal, P.R.A. Yatveer Singh, S.R.A.
Type of study	Internal
Date of start of study	01 October 2009
Duration and scheduled date of completion of study	03 years; 31 March 2012

Objectives of study

The envisaged objectives of the study are:

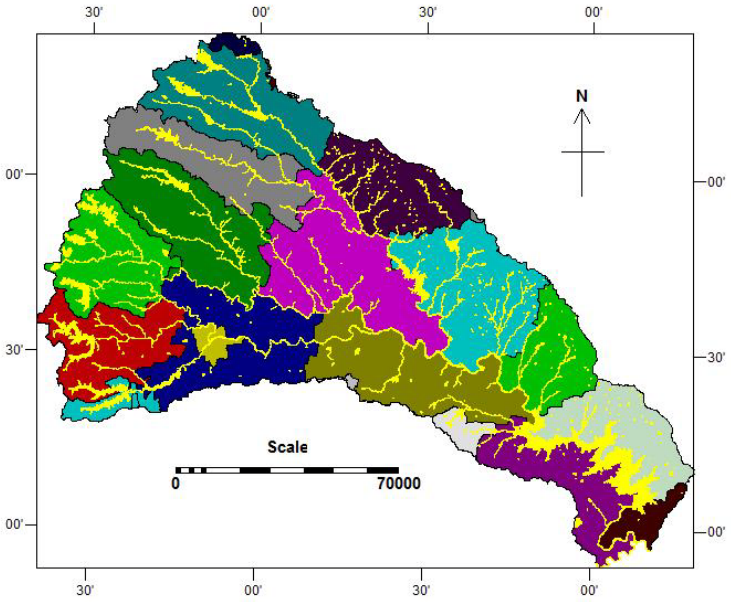
1. To apply a distributed hydrological model at the scale of a river basin and assess its effectiveness and limitations in light of data availability.
2. To compare the model results with a semi-distributed model for addressing various water related issues at the basin scale.

Statement of problem and brief methodology

This study focuses on the application of distributed hydrological models at the scale of a river basin and to assess their effectiveness and limitations in light of data availability in comparison to a semi-distributed model for integrated planning and management of water resources.

Location map/Study Area

The study is being carried out for the upper Bhima basin up to the Ujjani reservoir. It is a multi-purpose multi-reservoir system with catchment area of 14856 sq. km. There are 18 reservoir projects in the basin with total storage of 17.4 MCM and hydropower generation capacity of 318 MW. Major part of the basin is drought prone with extensive groundwater exploitation. Ten percent (10%) of the basin area is forested whereas agriculture is practiced on 76% of the basin area out of which 64% is irrigated. A map of the basin showing major drainage network, reservoirs, and sub-basins corresponding to different gauging sites is shown below.



Approved action plan

Year	Oct - Dec	Jan - March	April - June	July – Sept
2009-10	1. Database development 2. Download of models	1. Database development 2. Review of models	1. Database development 2. Review of models	1. Database development for Mike Basin and NIH models
2010-11	1. Database development 2. Application of Mike Basin model	1. Database development 2. Application of NIH model	Application of HEC/SWAT/ MODSIM model	Application of HEC/SWAT/ MODSIM model
2011-12	Application of HEC/SWAT/ MODSIM model	Comparison of results	-	-

Recommendations/suggestions in previous WG/TAC/GB meetings:

Recommendations	Action Taken
Dr. M. Perumal suggested that the results of the MIKE Basin will be better than the results of the HEC-HMS model.	The results of the NIH model will be compared with other models bringing out the advantages/limitations of distributed models in comparison to the semi-distributed models.

Achievement

Objectives (April 2011 – till date)	Achievements
1. Database development 2. Application of Mike Basin Model 3. Application of NIH Model 4. Application of other models	1. Database completed for Mike Basin/NIH models. 2. Application of Mike Basin and NIH models is in progress and will be completed by WG meeting.

Analysis & results

1. Model results (Mike Basin & NIH) will be presented in the WG meeting.
2. Other minor analysis and report writing are in progress, which may take 2 – 3 months for the completion.

Adopters of the results of the study and their feedback

This study will highlight the advantages/limitations of distributed modeling study at the scale of river basin. These results can be utilized for hydrological modeling for river basin planning and management.

Deliverables

Research papers and reports.

Report writing is in progress and shall be completed in 02 momths.

Data generated in the study

Distributed hydro-meteorological data has been generated in the study This includes data layers for basin boundary, DEM, drainage, slope, aspect, reservoir locations, land use, crop map, command area map, rainfall stations, river gauge stations, climate stations, sub-basins for different gauging stations, district, Thiessen polygons for rainfall and ET stations etc.

Study benefits/impacts

The study will suggest a better model to integrated river basin planning and management and will bring out the advantages/limitations of distributed models in comparison to the semi-distributed models.

2. Web based information system for major and important lakes in India

(Research study)

Study group	Deepa Chalisgaonkar, Scientist F Suhas Khobragade, Scientist E1
Type of study	Internal
Date of start of study	01 April 2010
Duration and scheduled date of completion of study	02 years; 31 March 2012
Study area	India

Objectives of study

1. To develop a framework for web-based information for major and important lakes in India.
2. To compile the information related to major and minor lakes of India.
3. To use web as a platform for the dissemination of this information to the users.

Statement of problem and brief methodology

This study focuses on the development of a web based information system for major and minor lakes of India.

The WEBLIS (**WE**b **B**ased **L**ake **I**nformation **S**ystem) software has been developed to provide hydrological and limnological information related to major and important lakes of India. Efforts have been made to include as much information as has been available from various sources. The lakes have been arranged state wise, and within a state district wise. Efforts have also been made to provide a list of organization of the various central government, state government, local bodies, Academic Institutes and NGO's which are involved in conservation, management or research related to lakes. A mini dictionary of the important terms related to Lake Hydrology and Limnology for the ready reference of the users has been incorporated. Important notes on various aspects of Lake Hydrology such as lake classification, morphometry, water balance, sedimentation, water quality etc have been provided.

Action plan

Year	April – Jun	Jul - Sep	Oct - Dec	Jan - Mar
2010-11	Planning the design of the Information system and development of the framework Review of Literature	Preparation of clickable map of India showing different states Review of literature	Preparation of clickable map of Rajasthan showing lakes of Rajasthan Review of literature	Review and Compilation of information related to 15 lakes of Rajasthan and about 20 other lakes of India
2011-12	Review, compilation and incorporation of the literature/ material to lake hydrology in the system	Preparation of clickable maps of MP, Uttarakhand, J & K, Punjab, Haryana and HP. Review and compilation of literature related to lakes of MP, Uttarakhand, J & K, Punjab, Haryana and HP.	Preparation of clickable maps of AP, Maharashtra, Karnataka, TN, Kerala etc. Review and compilation of literature related to AP, Maharashtra, Karnataka, TN, Kerala etc	Final testing, debugging and installation of Lake Information System

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

S.No	Suggestions of Working group members	Action Taken
1.	a) Reference to the source of information should be provided b) To update the system from time to time. (suggestions from Mrs. Laxmi).	a) References of the source of information have been included in the system. b) Efforts would be made to update the system from time to time with the availability of new information

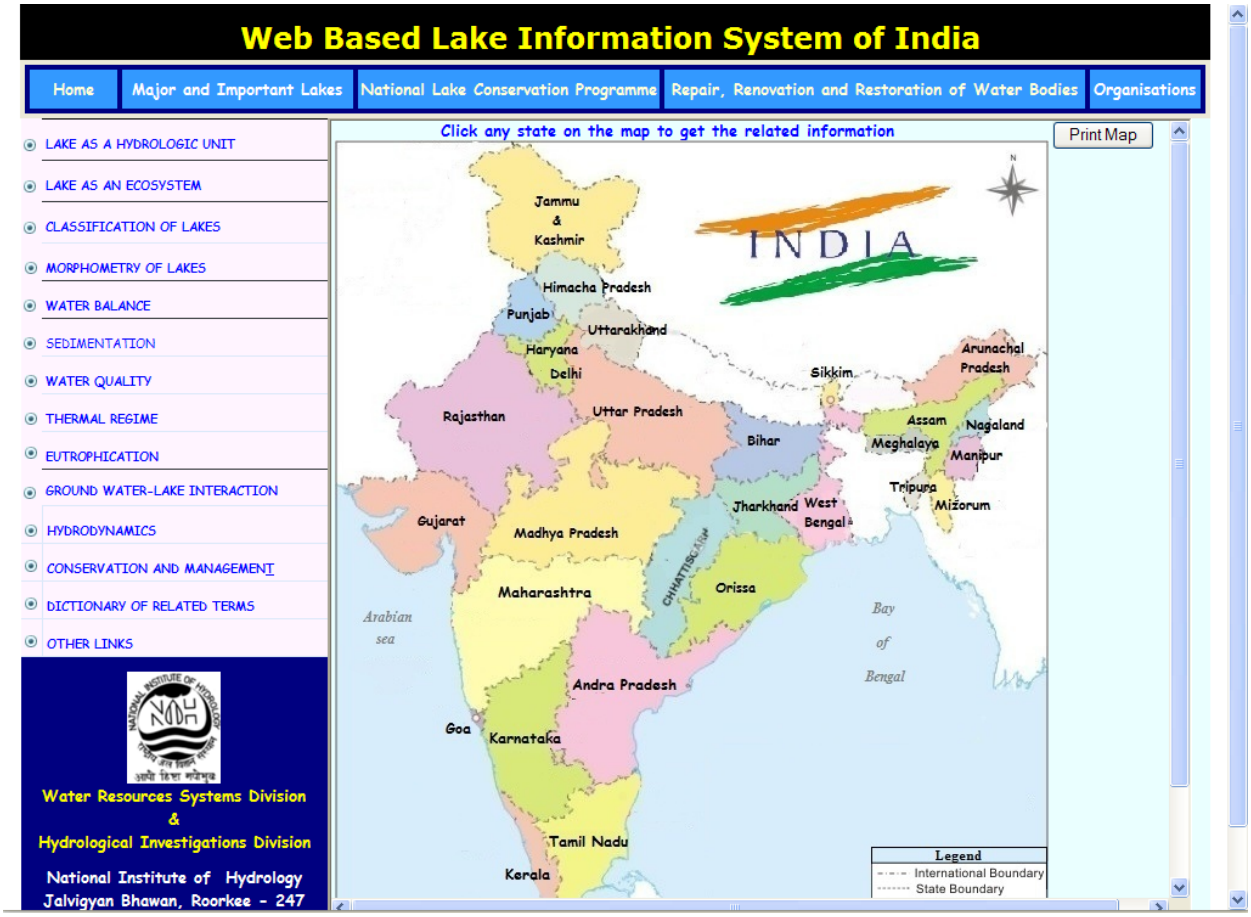
2.	Considering the information on lakes prepared by Sunita Narayan (suggestion from Dr. M. Perumal)	She was contacted and her assistant Mr Raja informed that no work has been done on lakes by them.
3.	a) To-include/ refer-to the GIGB guidelines given by the Govt for the security of the websites. b) To include/provide in the system the information about RRR and a two-way link to the information and updates from the Ministry's and CWC's sites maintaining such details. (suggestions from Sh Kishor Kumar)	Computer Centre of NIH will be maintaining the website, which will be requested for doing the needful regarding the GIGB guidelines once the fully developed system is handed over to the Computer Centre.

Achievements

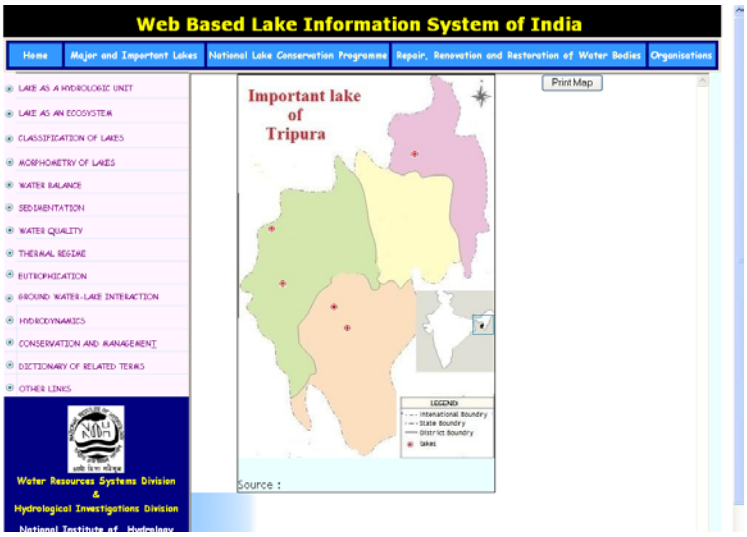
Year	Objectives (for the period October 2011- March 2012)	Achievements
2010-11 and 2011-12	1. Preparation of clickable map of, Maharashtra, Kerala, AP, Karnataka and TN	Achieved
	2. Review and Compilation of information related to 30 lakes of Maharashtra, Kerala, AP, Karnataka and TN	Achieved
	3. Preparation of clickable map of seven north eastern states of India	Achieved
	4. Review and compilation of information related to 25 lakes of North-eastern state of India	Achieved
	5. Compilation of list of organizations related to lakes	Achieved
	6. A mini dictionary of lake related terms	Achieved

Analysis and Results

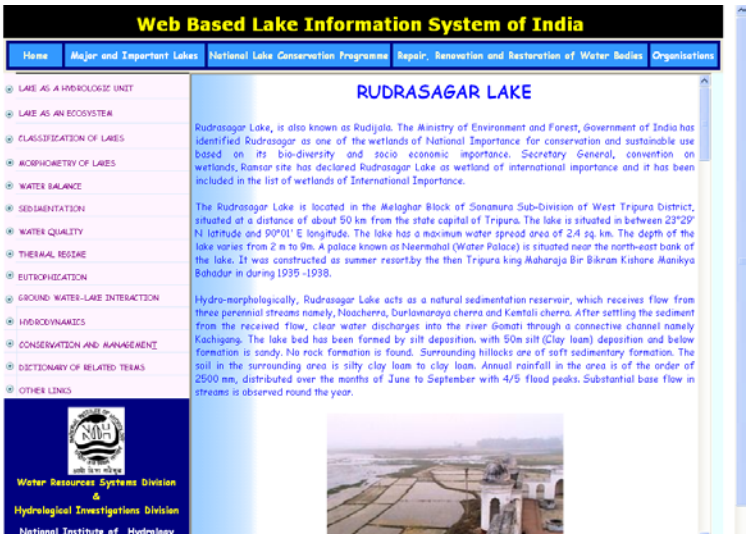
The clickable map of India showing different states has been prepared showing different states. The main screen of the WEBLIS is shown below in the Figure.



Similarly, the clickable maps of different states have been prepared and the lakes have been marked on them. Figure given below shows the clickable map of Tripura.



After developing the individual web page for the lakes, these web pages have been linked to the main page. The web page for Rudrasagar lake is shown below.



Similarly, individual web pages have been developed for various other information, viz., list of organizations etc and have been linked to the WEBLIS.

Efforts have been made to provide information related to the various studies carried out on the lakes so far, bibliography of the research carried out on the lakes till date. List of the various central government, state government, local bodies, academic Institutes and NGO's which are involved in conservation, management or research has also been provided. A mini dictionary of the important terms related to Lake Hydrology and Limnology has also been developed and has been included in WEBLIS for the ready reference of the users.

Adopters of the results of the study and their feedback

The software would be of help to all those who are working in the area of lake conservation and management. This information would also be of help to the policy makers, managers and field engineers who are directly involved in the management and conservation of the lakes.

Deliverables

WEBLIS Software has been developed. Report writing is in progress and shall be completed in a month. Two papers have been published.

Data generated in the study

The information related to lakes has been collected from various sources. The clickable maps of India and its states, showing the locations of the lakes, have been developed. Once a particular lake is clicked, information related to that lake would be available to the user. The data available from various sources have been compiled and made available to users.

Study benefits/impacts

The package intends to provide information regarding the various hydrological and limnological aspects of the major and important lakes of India. The information includes diagrams/text describing the lakes of India and data on water quality, water availability, sedimentation, sediment chemistry, biological data etc as reported by various researchers for different lakes. At present such a data based are not available in India. This is the first attempt of its kind. This information and data base would be of help to all those working in the area

of lake conservation and management for carrying out research or framing conservation and management measures.

There are thousands of lakes in India and attempt has been made to include as many lakes as possible. The WEBLIS will be installed on the *web server* and can be accessed through *WWW*. Presently, the information of only major and important lakes has been included. However, in future efforts would be made to add information on as many lakes as available.

3. Analysis of water management scenarios in Tapi River basin using MIKE Basin (Research study)

Study group	Rama Mehta, Scientist C M. K. Goel, Scientist F D. S. Rathore, Scientist E2
Type of study	Internal
Date of start of study	01 April 2010
Duration and scheduled date of completion of study	03 years; 31 March 2013

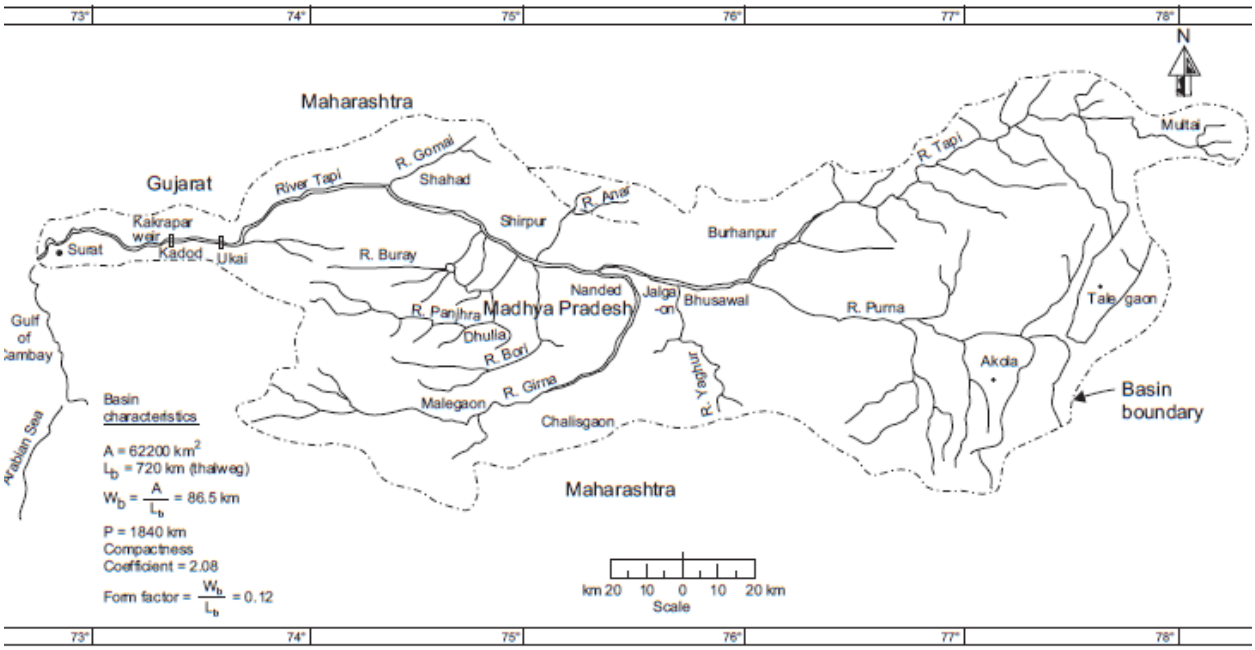
Objectives of study

1. Identification of water resources issues in the study area.
2. Model setup for Tapi river basin upto Ukai dam using Mike basin software.
3. Analysis of different water management scenarios.

Statement of problem

Tapi river basin modeling for water management issues using Mike Basin Software.

Location map/study area:



Approved action plan

Work	First Year 2010-2011	Second year 2011-2012	Third year 2012-2013
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. Rainfall Runoff modeling for each sub-basin using NAM model. 2. Mike basin modeling for Tapi basin with intermediate discharge from all sub-basins.			
1. Analysis of water management scenarios 2. Report writing and paper publication			

Recommendation / Suggestions in previous meeting of working group/ TAC/ GB

No specific recommendation/suggestion

Achievements

Objectives (for the period April 2011- March 2012):

Model set-up for Tapi Basin

Achievements:

1. Study of the model for its input data.
2. Completion the discharge series from rainfall data for few sites (where discharge was not available), rainfall-runoff modeling using MIKE ZERO has been done.
3. Routing models have been prepared for intermediate catchments.
4. Specific runoff series of upstream and intermediate catchments have been obtained for further analysis.
5. Average demands for different months for all sub-basins have been computed from previous study and used for naturalized flow in sub-basins.
6. For a particular sub-basin, a hypothetical conceptual reservoir is considered.

Objectives (for the period April 2012-March 2013)	Achievements
1. Analysis of water management with different demand scenarios 2. Report writing and paper publication	Finally the model will be run with demands from each sub-basin. The water (present/future) availability for fulfillment of demand will be obtained using model.

Analysis & Results

Will be presented in the Working Group meeting.

Adopters of the results of the study and their feedback

NTBO, State Agencies: Maharashtra, Gujarat, Madhya Pradesh

Deliverables:

Technical Report and Research papers

Data generated in the study

The hydrological and meteorological data collected/to be collected from the concerned divisions of NTBO offices in M.P., Gujarat and Maharashtra.

Study benefits/Impacts

1. The Study will give a better idea about Water Management Scenario of Tapi River Basin.
2. Knowledge of Mike basin software and its applications for Tapi basin for water management can be used for other river basins in India.

4. Development of analytical equation for alternate depths for flow in rectangular channels (Research study)

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

Date of start of study 01 April 2011

Duration and scheduled date of completion of study 01 year; 31 March 2012

Type of study Internal

Objectives of study

1. To develop analytical equation/solution for obtaining alternate depths in rectangular open-channels.
2. To illustrate and demonstrate the practical application of the developed analytical equation for solving hydrologic problems.

Statement of problem and brief methodology

Solution to problems concerning transition in the width and bottom of the channels requires computation of alternate depths.

Alternate depths are defined as the depths of flow in open channels for which the specific energy is the same. The objective is intended to be accomplished by analytically solving the relevant equation.

Action plan

Activity	I-Quarter	II-Quarter	III-Quarter	IV-Quarter
Review of literature and identification gaps				
Development of analytical solution/equation				
Application and illustrated examples				
Preparation of report				

Recommendation / Suggestions in previous meeting of working group/ TAC/ GB

Recommendation/suggestion	**Action**
Difference between the intended solution and that given in the book by Subhash (Enquiry from Dr. M. Perumal)	The derived solution is a generalized one and both alternate depths can be obtained from the known value of the specific energy

Achievement/progress

1. A handy analytical equation for easy and direct computation of the alternate depths for flow in rectangular open-channel flow has been derived by analytically solving the governing specific energy equation.
2. Practical utility and ease in application of the developed equation have been illustrated using specific examples.
3. The derived equation would be helpful in practical studies dealing with the open-channel flows, especially in the cases of transitions in width and bottom elevation of the channel.

Analysis and results

To be presented in the Working Group meeting

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

Deliverables

Research report detailing the developed equation and research papers. The writing of the report shall be completed in a month.

5. A transfer function model for event based runoff (Research study)

Study group Sushil K. Singh, Scientist F

Date of start of study 01 April 2011

Duration and scheduled date of completion of study: 01 year; 31 March 2012

Type of study Internal

Objectives of study

1. To identify the transfer function (TF) for event based runoff modeling.
2. To estimate the event based runoff using the identified TF, and to illustrate and demonstrate its usefulness in solving practical hydrologic problems.

Statement of problem and brief methodology

Event based rainfall runoff modeling has been a concern for practitioners, field engineers, and academicians.

1. A transfer function model is intended to be developed and its parameters are to be estimated. The TF model then would be ready for the estimation of event based runoff.
2. Published authentic field data (multiple-storm data) from different catchments are intended to be used for the illustration and assessment of the performance of the developed model.

Action plan

Activity	I-Quarter	II-Quarter	III-Quarter	IV-Quarter
Review of literature and identification gaps				
Development of transfer function approach and estimation of its parameters				
Application and analysis of results				
Preparation of report				

Recommendation / Suggestions in previous meeting of working group/ TAC/ GB

No specific recommendation/suggestion

Achievement/Progress

1. A transfer function (TF) model/approach for modeling event based runoff. The z-transform/backward-shift-operator has been used as transfer function modeling of runoff.

2. The parameters of the transfer function have been identified using the published multi-storm data; and the performance-evaluation of the TF approach has been illustrated using these data.
3. The developed model would be useful in practical studies dealing with the assessment and prediction of runoff due to a complex or critical rainfall event.

Analysis and results

To be presented in the Working Group meeting. The study is complete and the writing of the report is in progress and shall be completed in a couple of months

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

Deliverables

Research report detailing the methodology and research papers.

6. Trend and variability analysis of Rainfall and Temperature in Himalayan region (Research Study: New study)

Study Group

Scientists:
L. N. Thakural, Scientist B
Sanjay Kumar, Scientist E1
Sanjay K. Jain, Scientist F
Scientific staff:
Tanveer Ahmed, PRA

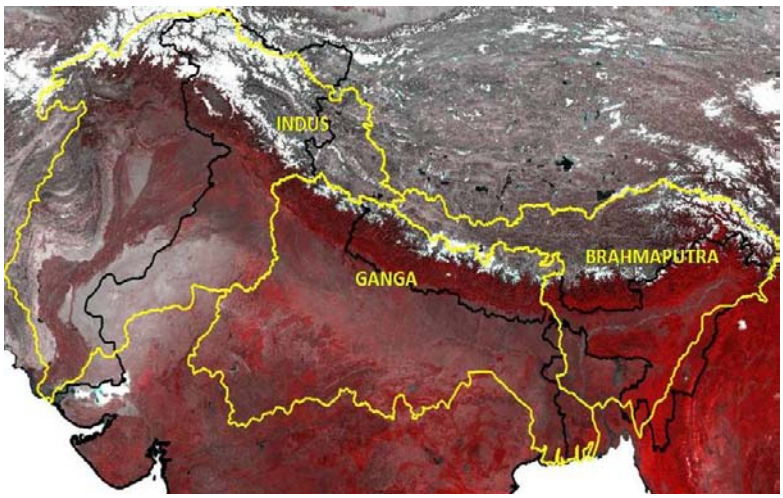
Type of study Internal

Date of start of study October 2011

Duration and scheduled date of completion of the study 03 years**;** 30 September 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. Database creation for the Himalayan region.
2. Temporal and spatial characteristics of the rainfall and temperature time series and their statistical distribution
3. Parametric approach for trend and variability analysis
4. Non-parametric approach trend and variability analysis
   (Note: "Descriptive and inferential statistical analysis of climatic parameters" as reported earlier is now substituted by as given at item 2 above)

Statement of the problem and brief methodology

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. 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.

This study is a step to understand the behavior of climate in Himalayan terrain of India which can be utilized for proper planning and management. 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.

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. The trends and variability analysis of rainfall and temperature time series would be evaluated using the following statistical techniques for various time scales.

1. Temporal and Spatial characteristics of the rainfall and temperature time series and their statistical distribution;
2. Parametric approach for trend and variability;
3. Mann-Kendall test and Sens's estimator of slope method (non-parametric) for trend and variability.

Action plan

S. No.	Major Activities	1st Year	2nd Year	3rd Year
1	Literature review			
2	Data collection & preparation for analysis			
3	Descriptive & inferential statistical analysis of time series of rainfall and temperature			
4	Analysis using parametric approach			
5	Analysis using non-parametric approach			
6	Preparation of report**	Part-1	Part-2	Part-3

** Reports: Part-1- Temporal and Spatial characteristics of the rainfall and temperature time series and their statistical distribution
Part-2- Analysis using parametric approach
Part-3- Analysis using non-parametric approach

Recommendation / Suggestions in previous meeting of working group/ TAC/ GB

No specific recommendation/suggestion

Achievement/Progress

APHRODITE data downloaded and GIS map prepared for the study area.

Review (identification of gaps).

Objectives (for the period October 2011-March 2012)	**Achievements**
1. Review of literature 2. Data collection 3. Collection of data base in GIS	1. Partially achieved 2. Partially achieved 3. Partially achieved

Analysis and results

To be presented in the Working Group meeting.

Data procured and generated during the study:

1. APHRODITE data downloaded and GIS map prepared for the study area.
2. Efforts are continued to collect additional recent rainfall and temperature data from BBMB, IMD, State Departments.

End users/beneficiaries of the study

Academicians, state and central government departments.

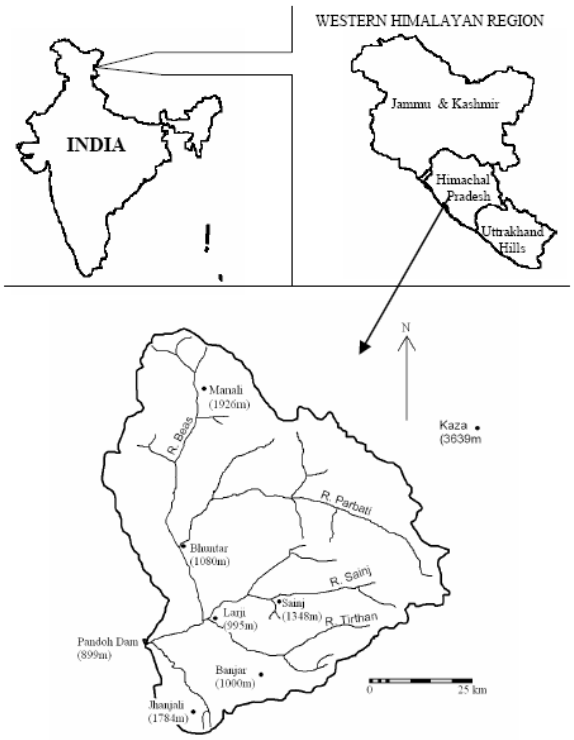
Deliverables:

Research papers and report

7. Integrated approach for snowmelt runoff studies and effect of anthropogenic activities in Beas basin (PDS under HP-II)

Study group	Dr. S. K. Jain, Scientist F Dr. S. P. Rai, Scientist E1 Mr. L. N. Thakural, Scientist B
Type of study	PDS under HP II
Date of Start	01 April 2009
Duration of study and scheduled date of completion	03 years**;** 31 March 2012

Location map / study area



Objectives

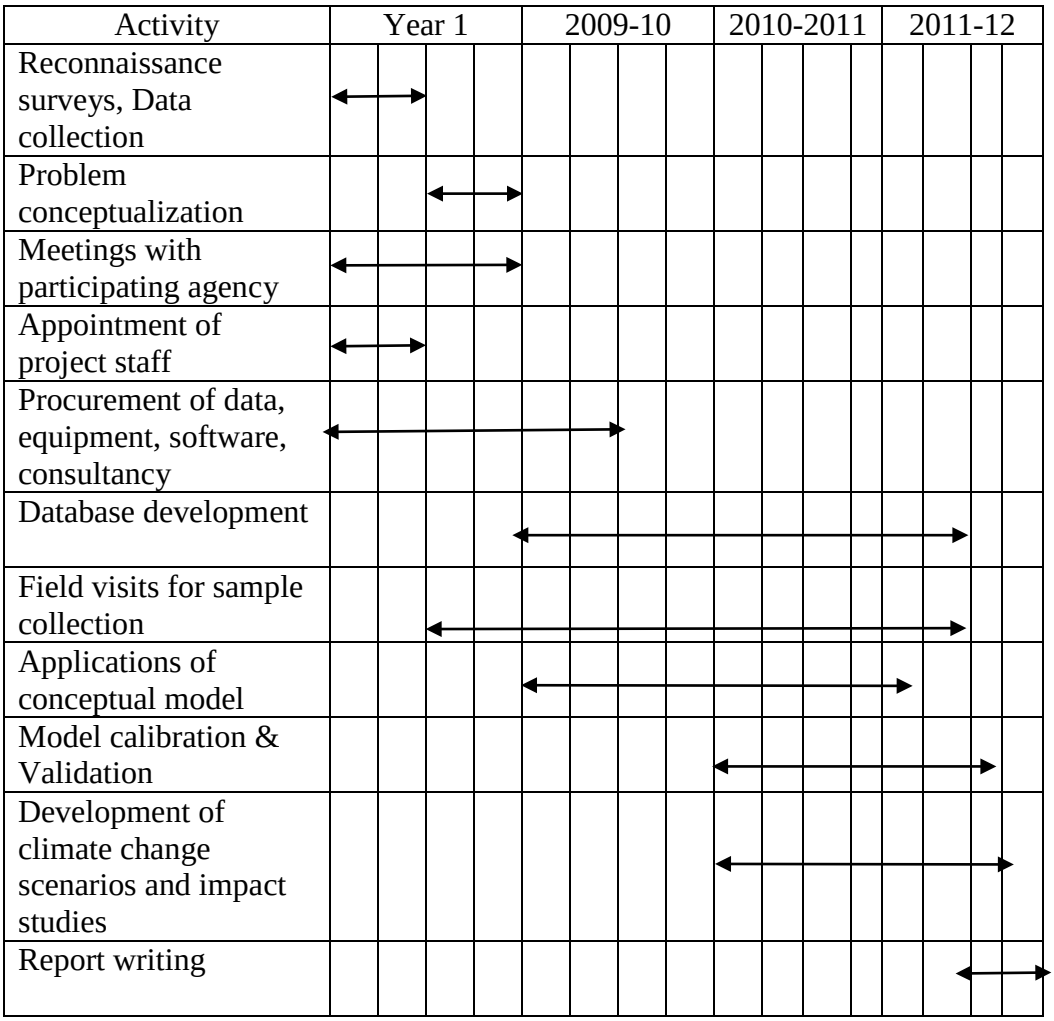
5. To create spatial data (consisting of snow cover area and DEM) and meteorological/hydrological data base for the study area
6. To estimate snow cover area and its temporal variation using remote sensing data.
7. To estimate snow melt runoff in Beas River at Pandoh dam.
8. To study the composition 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.
9. To study trend of precipitation, temperature and stream flow in Beas basin using parametric and non parametric approaches, and
10. To investigate the impact of likely future changes in climate on stream flow in the study area using GCM/RCM based scenarios.

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.

Approved action plan

Approved work plan is as follows (initially proposed 4-year plan was later rescheduled to 3-year ending in the year 2011-12).



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

There was no specific recommendation pertaining to the study.

Achievements

Year	Objectives (for the period April 2010 - March 2012)	Achievements
2010-11 2011-12	1. Analysis of data and trend analysis	Achieved
	2. Creation of data base in GIS	Achieved
	3. Simulation of snowmelt runoff model	Achieved
	4. Generation of climate change scenarios	Under progress
	5. Samples collection from the field	Achieved
	6. Analysis of samples	Under progress

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. In this connection, a visit to IISc., Bangalore was made in December 2011. This work will be over by the end of April, 2012 and progress made so far will be presented in the meeting.

For carrying out isotopic analysis, samples have been collected from a number of sites. Weekly samples have been collected from all the sites for the period April 2011 to October 2011. Analysis of these samples is under progress and results will be presented during the meeting.

The results of the analysis will be presented during the meeting.

An extension of four months is required to complete the study.

Adopters of the results of the study and their feedback

Bhakra Beas Management Board

Deliverables

Reports and research papers

Data generated in the study

Snow-cover maps from satellite data. Samples collected from the field, stream flow hydrographs etc.

8. Assessment of Effects of Sedimentation on the Capacity/ Life of Bhakra Reservoir (Gobind Sagar) on River Satluj and Pong Reservoir on River Beas

(PDS under HP-II)

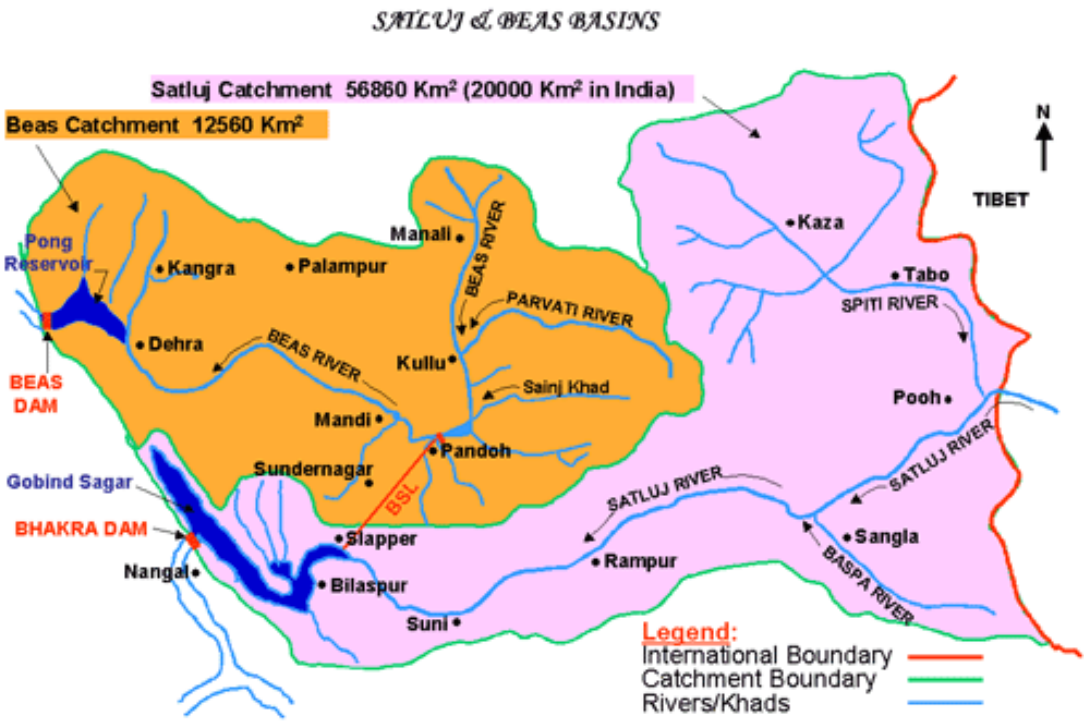
Study Group Dr. Sanjay K. Jain, Scientist F
Dr. J. V. Tyagi, Scientist F
Mr. D. S. Rathore, Scientist E2
Dr. Rama Mehta, Scientist C

Type of study PDS under HP II

Date of start of study 01 April 2009

Duration and schedule date of completion 03 years**;** 31 March 2012

Location map / Study area



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.

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.

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

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

On suggestion from Dr. Grewal, Dr. S. K. Jain informed that the work at Largi in Beas basin for soil erosion will be consulted for the present study

Achievements

Year	Objectives (for the period April 2010 – March 2012)	Achievements
2010-11	1. Analysis of data and sediment rating curves	Achieved
2011-12	2. Creation of data base in GIS	Achieved
	3. Processing of satellite data	Maps have been prepared
	4. Assessment of sediment rate	Achieved
	5. Modeling of sediment yield	Under process

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.

Satellite data for both the catchments i.e. Satluj up to Bhakhra and Beas up to Pong have been procured. Land use map have been prepared. 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 Satluj basin. The progress will be presented in the meeting.

Extension of four months is required to complete the study.

Adopters of the results of the study and their feedback

Bhakra Beas Management Board

Deliverables

Reports and research papers

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.

9. Hydrological assessment of ungauged catchments (small catchment)

(PDS under HP-II)

Study group Scientists:

Pradeep Kumar Bhunya, Scientist E1

Rakesh Kumar, Scientist F

D. S. Rathore, Scientist E2

Sanjay Kumar, Scientist E1

P. C. Nayak, Scientist C

Scientific staff:

P. K. Agarwal, P.R.A.

Tanveer Ahmed, P.R.A.

Yatveer Singh, S.R.A.

N. K. Bhatnagar, S.R.A.

Anju Choudhary, S.R.A.

U. V. N. Rao, S.R.A

Representative Nodal Officer from Govt. Of Orissa :

(i) Director (Hydrology and W.R. Planning-I), Govt. Of Orissa, (ii) Er. S K Malik (Deputy Director) and (iii)Er. S B Mohanty (Assistant Director) at Director of Hydrometry, Govt. Of Orissa.

Type of study PDS (Under HP-II)

Date of start of study May 2009

Duration of the study and scheduled date of completion 03 years (2009-2012); May 2012

Objectives of the study

To calibrate and validate an event based model employing unit hydrograph approach to the available data of flood events for the gauged catchments in the region.

To identify few robust flood frequency distributions that may be used for the computation of return period flood for the gauged catchments in the region, and to develop regional flood formulae using statistical correlation of the observed peak characteristics with important catchment and storm characteristics, for the estimation of the peak, and time to peak for the ungauged catchments in the region.

To develop regional unit hydrograph, and regional flood frequency analysis procedures utilizing the available data and methodologies.

To develop methodology for the regionalization of the hydrological parameters for the computation of the water availability for the ungauged catchments in the region.

Study area and location map

The Ministry has recommended small catchments in Mahanadi basin as a study area for this project (ref: Letter No. 12/94/2005-B & B/VOL-V/922-953 dated 3/9/2008). Since the basins of Rushukulya and Brahmani are near Mahanadi and has a confluence at *Puri* and *Cuttack* districts, a few selected small catchments from these two basins are envisaged to be included in this project so as to make the results refined.

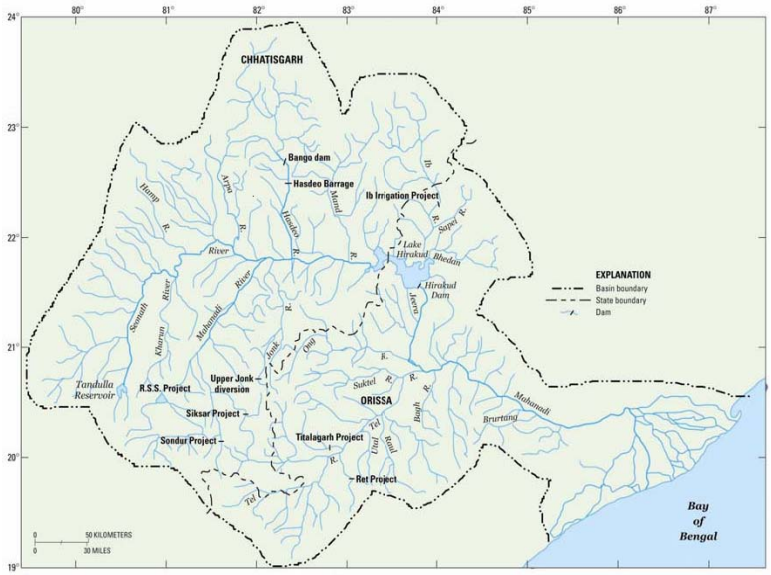


Figure: Mahanadi basin in *Orissa* and *Chatisgarh* states.

Statement of the problem and brief methodology

Briefly the following steps are followed for this study:

(i) Testing few homogeneity tests. (ii) Regionalize the *pdf* parameters used for transmuting the UH using available UH for a region., (iii) Regional formulae for peak flow and time to peak of UH for the region on basis of geomorphological characteristics of the basins using new methods like ANN, Fuzzy and non-linear regression model, (iv) Explore the potentiality of new synthetic unit hydrograph methods (gamma, beta, Weibull) and identify the best method for the region, (v) Regionalization of parameters of the robust AMS model, (vi) Deriving regional formulae, (vii) Regional formulae for q (T) using regression techniques, (viii) Peak over threshold methods, (ix) Regionalization of flow duration curves using available data, (x)Uncertainty and risk factor analysis

Approved action plan and expected outcome

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 expected outcome from the project.

1. Regional unit hydrograph relationships for the region are to be developed. Knowing the catchment characteristics for an ungauged catchment in the region from the available topographical sheet and climatological data, the UH for that catchment can be derived for the region. 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.
2. Recommend a standard statistical distribution procedure for homogeneity tests.
3. 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.
4. Recommend a standard POT method for return period flood computation when the annual maximum series is short.
5. Regional flow duration curve to estimate the dependable flows for the ungauged catchment.
6. A menu driven software to accomplish the above works.

The bar chart for scheduled action that is being followed is as follows:

Sl	Technical Component	Technical Activity	09-10		10-11		11-12	
			1	2	1	2	1	2
1.	Literature survey and watershed identification and data collection.	Literature survey (PKB, RK, DSR)						
		Watershed survey (PKB, Project staffs)						
		Collection of historical data and primary investigation and verification of data (PKB, PCN, and Project staffs)						
2	Analysis of GIS data	Collection of satellite imageries, toposheets (SOI) (PKB, DSR)						
		Digitization of data, analysis, interpretation for land use and geomorphological data with change interpretation, and reporting of results (PKB, DSR)						
3	Model application (Flood frequency analysis, Regional flood, Regional Unit hydrograph, Rating curve and Regional flow duration formulae)	Processing and application of available models to storm and flood data (PKB, RK, SK, PCN and project staffs)						
		Programming & model application analysis using available storm and flood data and use it for ungauged catchments. (PKB, RK, SK, PCN and project staffs)						
		Interpretation & reporting of results(PKB, RK, DSR, SK, PCN)						
4	Model development (Extrapolation, pruning, network size and	Application of available models, and using other software like Mat lab, Mathematica, Systat etc. to combine them and use. (PKB, RK, DSR, SK, PCN)						

	generalization)	Processing of storm/flood (daily/hourly time period scales) for concurrent periods(PKB, RK, SK, PCN and project staffs)							
		Analysis, interpretation & reporting of results(PKB, RK, DSR, SK, PCN)							
5	Application of recent SUH models	Available model understanding (PKB, RK)							
		Programming & model application (PKB)							
		Analysis, interpretation & reporting of results(PKB, RK, SK)							
6	Application of allied hydrological models.	Model development (PKB, RK, SK)							
		Programming & model application (e.g. parameter optimization, regionalize of independent parameters in zone etc.) (PKB)							
		Analysis, interpretation & reporting of results(PKB, RK, DSR, SK, PCN)							
7	Final report	Summarization of all the above results & reporting (PKB, RK, DSR, SK, PCN)							
8	Dissemination of outcome	Three training courses have been organized and one is proposed at Bhubaneswar during May 2012 (PKB, RK, DSR, SK, PCN and project staffs)							

Completed	
To be done	

RK: Rakesh Kumar, Sc-F; DSR: D S Rathore, Sc-E2;SK: Sanjay Kumar, Sc-E1; PKB: P K Bhunya, Sc-E1; PCN: P C Nayak, Sc-C.

Recommendations in the last WG meeting

There was no such critical suggestions and recommendations from the working group

Achievements

Six major objectives have been stressed during this period, and they are summarized as follows:

1. Refined the results of regional flood formulae for Mahanadi small catchments in reference to CWC report. and add some results from Brahmani and Rushukulya basins, which are nearby Mahanadi basin.
2. Updated the *morphological parameters (data), and their variations (regional) for the Mahanadi small catchments from imagery and respective toposheet. It was for twenty-six (26) small bridge catchments*
3. A detail results regarding the morphological parameters, and their variations(regional) for the Mahanadi small catchments from imageries interpretation has been used for GIUH. Using GIS, and available toposheet, multiple map overlays were prepared for matching the geomorphic and basin characteristics and their corresponding changes. This was in addition to the earlier regions (catchments). In addition, renaissance survey were conducted with field visits. Land-use conditions including change in geomorphology, was studied using a sweep method to view both the imagery and respective toposheet in Arc-GIS.
4. Table the short-term flood events for use in hydrograph derivation and SUH development, along with the UH parameters in regional scale. Completed the

hydrograph derivation and *SUH development*, along with the *UH parameters in regional scale*, using available short-term flood events. Three more pdfs were used for SUH derivation.

5. Developed the rating curves regional flow duration curves with the recently procured data. This was for twelve GD sites.
6. *AMS and POT methods* have been used *testing robustness*. This is *for the available flood data* in the region.

Three training course has been organized under India-Hydrology Project Phase-II. The last course was organized during July 25-29, 2011. The participants were from different states (coming under HP2), e.g. Orissa, AP, HP, Chatisgarh, Karnataka, Maharashtra, and Gujarat. As per the participants requests a training course on such allied topics has been discussed with Director (Hydrometry), Bhubaneswar and proposed during first part i.e. during May 2012..

Results achieved during this period (Oct 2011- March 2012)

The last objective (refer Sl. 5) i.e. rating curves and flow duration curves with the recently procured data has been completed up to 2009 that covers twelve GD sites i.e. for *Altuma, Chmpua, Tikerpada, Jenapur, Sundergarh, Pamposh, Talcher, Kesinga, Jaraikela, Gomlai, Kantamal,* and *Sukma***.** Four methods which are Grigorton, Weibull, Blom's and Cunnane plotting position formulae was used for this process. The results are for some stations are compared with results obtained by CWC earlier (CWC: 4) in their report for sub-zone-3(d). For the above sites flow duration curves have been completed as per CWC guidelines and regionalized parameters have been evaluated. Two software that was proposed earlier i.e. Mathematica , and Matlab has been procured with some basic/preliminary training. The softwares are being use in some cases for the project study e.g. parameter estimation for regional basis.

With the recently procured data, two works referring to objectives (1) & (3) have been completed as follows: SUH development using short-term flood events for use in hydrograph derivation and, along with the UH parameters in regional scale. For this analysis, data that were collected from different literatures (published works, report, CWC report (ref:4) and some from the water resources department (Govt. of Orissa) were used. A part of the rainfall events were checked with IMD data . The vital works during this phase is summarizing the morphological parameters, and calculating their variations(regional) for the Mahanadi small catchments from imageries interpretation. These were used for SUH, and GIUH studies. The variation in these morphological data were checked with CWC report (ref: 4). The objective given in (6) pertaining to flood estimation using AMS and POT methods with daily data have been completed in five steps: (i) testing of robustness of certain distributions, (ii) testing of a flood frequency distribution fitting the available flood data, (iii) Estimating bias, (iv) parameter estimation for regional flood formulae, (v) POT analysis. The results were published in two international journals given in reference (ref:1-3).

Since this activity has been planned for the last phase in the project period, and the project report has to be submitted by June 2012, some rest works has to be done in priority, and they area as follows: (i) encamping sub-programs (sub-computation) dealing vitally for developing a user-friendly tool for the PDS, (ii) Out of the results

obtained so far, some technical papers have been submitted for review, so that the methods and approach might be examined and be fruitful, (iii) As per the requests of some of the participants, a training course on such allied topics has been discussed with Director (Hydrometry), Bhubaneswar and proposed during this year in Orissa

Adopters of the results of the study and their feedback

Ministry of Water Resources under Govt. Of Orissa, and CWC, New Delhi.

Deliverables:

Research papers, user friendly menu and catalogue with focus on a real problem, that of estimating design flood magnitude at sites with either short records, or no flow data at all.

Data generated in the study

Type of data	Stations / basins	source
Gauge and Discharge data (daily time scale)	23 small catchments on Mahanadi (3d sub-zone) for 34 years (1957-1987) and collected data from 22 sites for the year 1970-2008 viz: *Indupur, Kharaimal, Jenapur, Naraj, Pamposh, Rengali, Talcher, Tikerpada, Akuapada, Alipingal, altuma, Sukma, Champua, Gomlai, jamadarpali, Jharaikela, Kantmal, Keonjhar, Kesinga, Parmanpur, Salebata, Sundergarh*	(i) CWC reports for sub zones, (ii) CWC office, Bhubaneswar, (iii) Directorate (Hydrometry) office, Bhubaneswar
Discharge data (AMS) and G & D data	20 stations on Mahanadi and Brahmani with prominent GD sites are: Tikarpara, Sukuma, Kantamal,Kesing,Pandigaon,Salebhata,Sundergarh	Department of Hydrometry, Govt. of Orissa, and Irrigation department
Discharge data (AMS)	Peak flow data of 3a, 3b, and 3f sub zones	CWC reports for sub zones
Peak hourly - runoff data during floods	23 small catchments on Mahanadi along with 10 other streams	Department of Hydrometry, CWC
Geomorphological data like L, Lc, A and slope	23 small catchments on Mahanadi	(i) CWC reports for sub zones. (ii) SOI toposheets (iii) RS imageries
Rainfall data	Daily maximum and annual for Mahanadi region.	Reports from Department of Hydrometry,

Study benefits/impacts

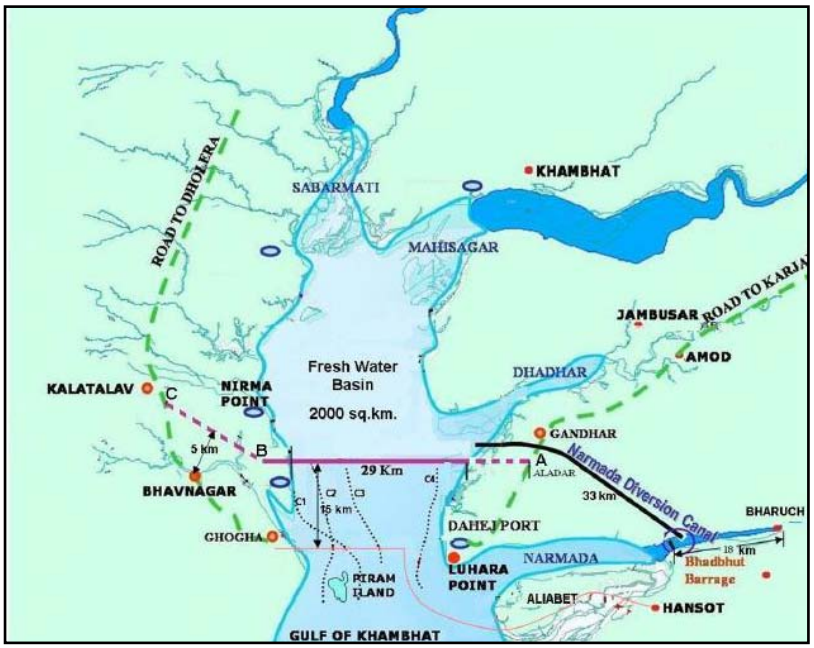
The study shall give as an user friendly menu and catalogue with focus on a real problem, that of estimating design flood magnitude at sites with either short records, or no flow data at all. This shall focus on two types of flood analysis i.e. with short-term data and daily or annual maximum data base. It would be useful for the Hydrological Design Aids project under HP-II.

10. Vetting of water availability studies of the gulf of khambhat development project (Kalpasar Project) (Consultancy project)

Study Group	M. K. Goel, Scientist F P. K. Agarwal, P.R.A. Yatveer Singh, S.R.A.
Type of study	Consultancy
Cost of project	7.99 Lakh
Start Date	29 April 2010
Scheduled date of completion	31 March 2012.

Location map/study area

The Kalpasar project visualizes a gigantic fresh water lake-dam to be created by closing the Gulf of Khambhat (in the Arabian Sea) and thereby harness the excess water of Narmada, Mahi, Sabarmati, Dhadar rivers and other small rivers for generating tidal power, irrigation, drinking and industrial purposes. A road link will also be set up over dam to reduce the distance between Saurashtra and South Gujarat.



11. Snowline estimation snowmelt runoff study and Glacial Lake Outburst Flood study for Kuri-Gongri H.E. Project in Bhutan (NHPC, Faridabad)

(Consultancy project)

Study Group	Sanjay K. Jain, Scientist F A. K. Lohani, Scientist E2 Sudhir Kumar, Scientist F L. N. Thakural, Scientist B Anju Chaudhary, S.R.A. Tanvear Ahamd, P.R.A.
Type of study	Consultancy
Cost of project	21.10 Lakh
Start date and duration:	December 2010, 09 months
Status	Draft report submitted

Proposed Work Programme for the year 2012-13

12. Mathematical representation of elevation-area-capacity curves for Indian reservoirs (Research study)

Study group Scientists:
M. K. Goel, Scientist F
Sushil K. Singh, Scientist F
Scientific staff:
P. K. Agarwal, P.R.A

Date of start of study April 2012

Duration and scheduled date of completion of study: 01 year; 31 March 2013

Type of study Internal

Objectives of study

The envisaged objective of the study is to develop mathematical relationships for characterizing elevation – area and elevation – capacity curves for Indian reservoirs.

Statement of problem and brief methodology

Prediction of reservoir inflows for specific rate of rise in reservoir levels has been a common concern of hydrologists, which is generally accomplished using the interpolation of elevation-area and elevation-capacity curves. Mathematical relationship for these curves and their possible generalization would enhance the accuracy and ease in application.

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, 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 and in predicting reservoir inflows using rate of rise.

Action plan

Activity	I-Quarter	II-Quarter	III-Quarter	IV-Quarter
Review of literature and collection of data				
Computerization of data Development of mathematical relationship				
Possible generalization of the mathematical relationship and its application/utility				
Preparation of report				

Expected outcome

Mathematical relationships for elevation-area and elevation-capacity curves for various Indian reservoirs and their possible generalization.

Adopters of the results of study

This study can be used by the dam authorities and water resources departments dealing with the reservoir operation in particular and hydrological modeling in general.

Deliverables

Research report and research papers.

13. WebGIS based snow cover information system for Himalayas

(Research study)

Study group Scientist:

D. S. Rathore, Scientist E2

Deepa Chalisgaonkar, Scientist F

L. N. Thakural, Scientist B

Scientific staff:

Tanveer Ahmad, P.R.A.

Date of start of study April 2012

Duration and scheduled date of completion of study: 01 year; 31 March 2013

Type of study Internal

Objectives of study

The objective of the study is to publish snow cover information on web/ intranet using GIS server for Himalayas.

Statement of problem and brief methodology

The information on snow cover is available over internet. This information is based on MODIS sensors and may be provided on web/ intranet in WebGIS environment. Sub basins may also be derived from DEM namely GLOBE, in GIS. Snow cover information may be disseminated sun basin wise.

Snow cover thematic maps derived from MODIS satellite are available from internet for Himalayas. These maps will be utilized. Topographic information is available in form of GLOBE DEM. Methodology consists of the following steps.

1. Snow cover maps prepared from MODIS will be downloaded from internet.
2. Sub basin maps will be extracted from GLOBE DEM.
3. Snow cover extent for sub basins will be extracted from snow cover thematic maps.
4. Snow cover information for elevation zones will also be provided.

Action plan

Activity	I-Quarter	II-Quarter	III-Quarter	IV-Quarter
Download of data				
Processing of the data				
Preparation of WebGIS application				
Writing of report				

Expected outcome

Web/intranet information system for obtaining snow cover in Himalayas using Map Server WebGIS software.

Adopters of the results of study

Policy makers and planners, line departments

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Deliverables

Research report and research papers.

14. Software for Frequency Analysis in Hydrology (Research study)

Study group	Deepa Chalisgaonkar, Scientist F Sushil K. Singh, Scientist F D. S. Rathore, Scientist E2 M. K. Goel, Scientist F
Date of start of study	April 2012
Duration and scheduled date of completion of study:	01 year; 31 March 2013
Type of study	Internal

Objectives of study

To develop a menu driven, interactive software for frequency analysis using different distributions.

Statement of problem and brief methodology

A common concern in many areas of water resources engineering is that of analyzing hydrological and meteorological events for planning and design purposes. For these purposes, information is required on rainfall, flow depths, discharges, evapotranspiration levels, etc. for a selected probability or return period. Use of historical record are required for application of frequency distributions in several areas of hydrology, viz., flood frequency analysis, hydrology of extremes, probabilistic analysis of rainfall, snowfall, etc. (Benson, 1950; Chen et al., 1974; Cong et al., 1979; Steadinger and Cohn, 1986; Cohn and Stedinger, 1987; Hirsch, 1987; Hirsch and Stedinger, 1987; Helsel and Cohn, 1988; Wang, 1990; Guo, 1990; Ouarda et al. 1998, Frances, 2001, Blainey et al., 2002).

It is proposed to develop a menu driven, user-friendly software 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.

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. The software will allow input from combination of different sources.

Action plan

Activity	I-Quarter	II-Quarter	III-Quarter	IV-Quarter
Review of available softwares, and Planning/ designing the framework of the software				
Review of literature and software development				
Final testing, debugging, and fine-tuning of the software				
Writing of report				

Expected outcome

A menu driven, user-friendly software 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.

With the hydroinformatics system proposed in this software it is possible 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.

Adopters of the results of study

The developed software will be a user friendly tool that can be used by practitioners for solving frequency analysis problems in the field of hydrology.

Deliverables

Software, research report, and research papers.

15. Event-based rainfall-runoff modelling using soft computing techniques

(Research study)

Study group	Scientists: Rama Mehta, Scientist C Sushil K. Singh, Scientist F Scientific staff: Yatveer Singh, S.R.A.
Date of start of study	April 2012
Duration and scheduled date of completion of study:	01 year; 31 March 2013
Type of study	Internal

Objectives of study

To model the event-based rainfall-runoff using soft-computing techniques, viz., ANN and ANFIS, considering the basin-wise multi-storm data.

Statement of problem and brief methodology

Modelling 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 modelling. 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 and of data				
Development and application of soft computing methods for rainfall-runoff modelling				
Testing, evaluation, and comparison with different methods				
Writing of report				

Expected outcome

1. A soft-computing techniques/procedure for event-based rainfall-runoff modelling.
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

RESEARCH COORDINATION AND MANAGEMENT UNIT

Scientific Manpower

S N	Name	Designation
1	Dr V C Goyal	Scientist F & Head
2	Dr R V Kale	Scientist B
3	Sri Subhash Kichlu	PRA
4	Sri Rajesh Agarwal	RA

WORK PROGRAMME FOR THE YEAR 2011-2012

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

PROPOSED 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)	DOS: Apr 2012 DOC: Mar 2013 **(New Study)**
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 **(New Study)**

WORK PROGRAMME FOR THE YEAR 2012-13

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, RCMU
   Co-PI **:** Dr. V. C. Goyal, Sc F and Head, RCMU

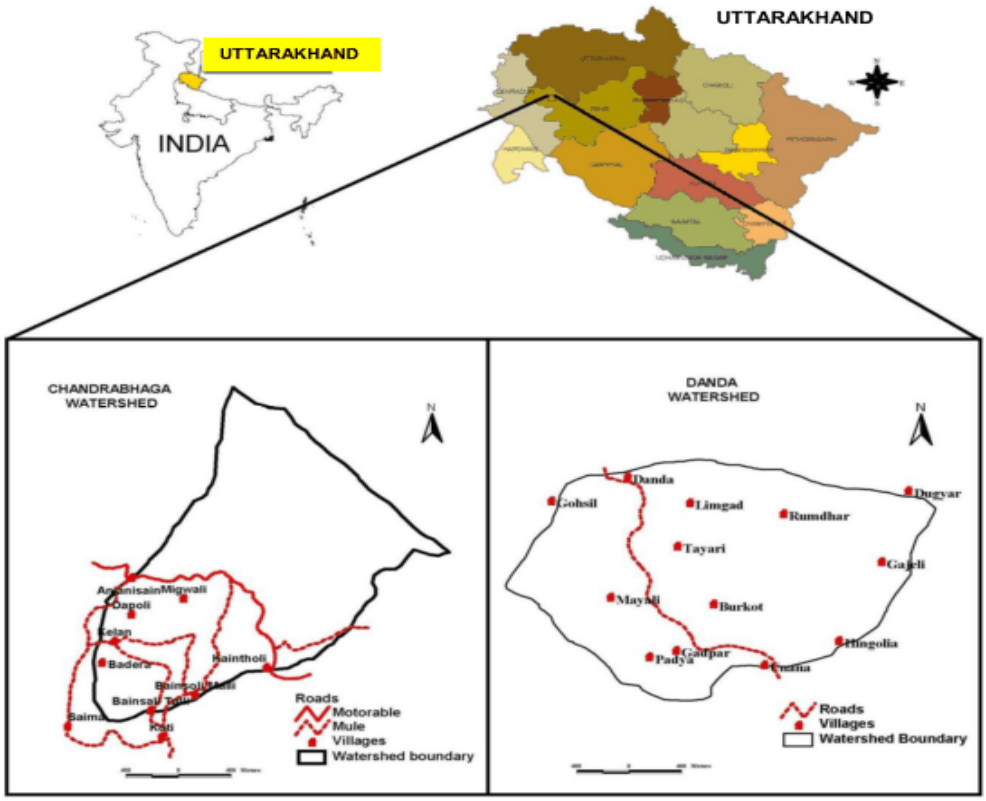
3. **Type of study**

   Internal (NIH funded)

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

5. **Scheduled date of completion:** March 2013

6. **Location map:** The study is being carried out for two small watersheds in the State of Uttarakhand, India. In these Himalayan watersheds number of springs found which are reliable sources of, clean water supply for drinking and domestic use. The geographical location of these watersheds is shown in following map.



7. **Study objectives**

   I. To develop a technique to assess the reliability of the spring flow as a sustainable source of drinking and domestic water by analyzing the flow

characteristics

II. To assess the potential for springs development as a water source

8. **Statement of the problem**

Springs in the Himalayas, in the Western Ghats and other places in India are the main source of drinking water due to logistical difficulty in creating storage for water. In such areas, majority of spring are of small orders which become dry during summer months. Flow/discharges in such springs vary considerably depending on the catchment characteristics (e.g. area, hydrogeology) and recharge in the catchment. The knowledge about the number of springs as well as their flow characteristics is important in the sustainable development of the water resources of these areas. The study of spring flow analysis has relevance to the water supply to rural areas, specifically hilly areas. As in many locations, rural development agencies would like to develop water resources of the catchment but lack the necessary hydraulic information. Further, the measurement and prediction of spring flows in aquifers are critical to water resources managers to maintain preferred flows based on the effect that current and projected ground water withdrawals have on water levels. Subsequently, the assessment of spring flow using physically based model requires the knowledge of fundamental input parameters such as hydraulic conductivity, specific yield and effective hydraulic conductivity describing the subsurface hydrology which are most problematic to obtain. Since well-drilling to estimate hydraulic parameters is often prohibitively expensive in developing countries, recession flow analysis is a very cost-effective and accurate alternative.

9. **Approved action plan**

Action plan: The collected spring flow and rainfall data will be analyzed for continuity and consistency of the record. In next step, the 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

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 Oct., 2011</u>** • Review of literature is in progress • Collection and preprocessing of required spring flow data is completed and a fully automated objective-based method (adapted matching strip method) for Master recession curve separation is chosen for analysis
	<u>Oct., 2011 – March, 2012</u> • Review of literature is in 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 the springs in the Chandrabhaga watershed using above mentioned method is almost completed • Major work on the mentioned objective is in progress
To assess the potential for springs development as a water source	• Work on the mentioned objective is in progress

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

Recommendations/suggestions	**Action taken**
No specific suggestion/comments	NA

12. **Analysis and Results**

- The spring flow and rainfall 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 [Completed before last working group meeting].
- Time-series spring flow data is available on daily basis from July, 1999 to Feb., 2001 daily while from 20 Feb, 2001 to 31 Dec., 2004 once in two days spring flow data 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 are in progress. An optimal master recession curve obtained for spring [spring#10] at Anajanisain village in the chandrabhaga watershed is shown along with spring discharge hydrograph and flow duration curve in the following figures. All the results for the other springs in these two watersheds will be presented during the 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 course of the study.

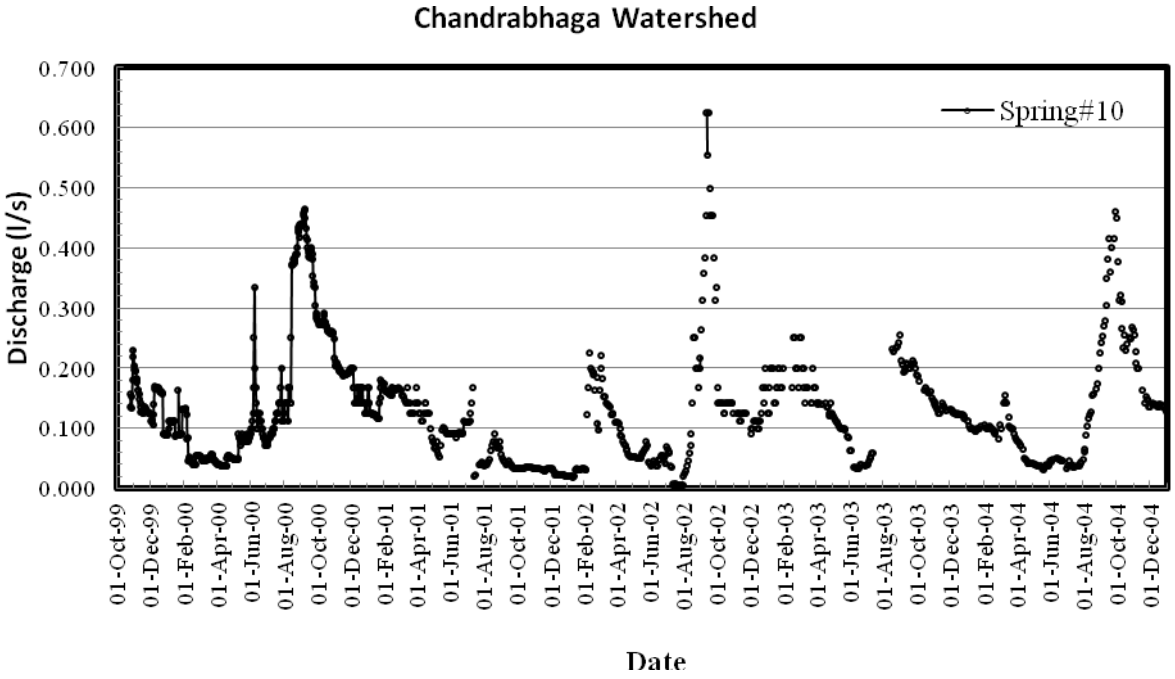


Figure 1. Observed spring discharge hydrograph at Anjanisain (Spring#10) in Chandrabhaga Watershed.

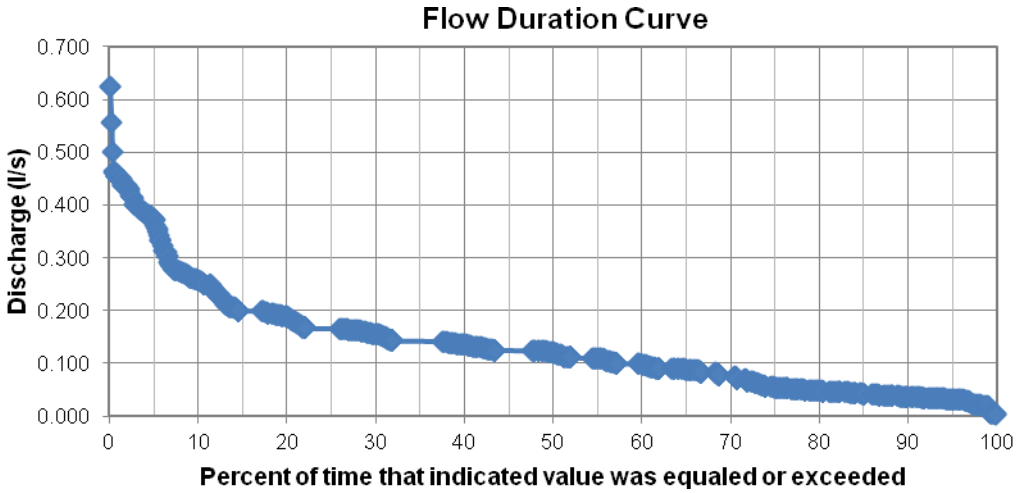


Figure 2. Flow duration curve for spring#10.

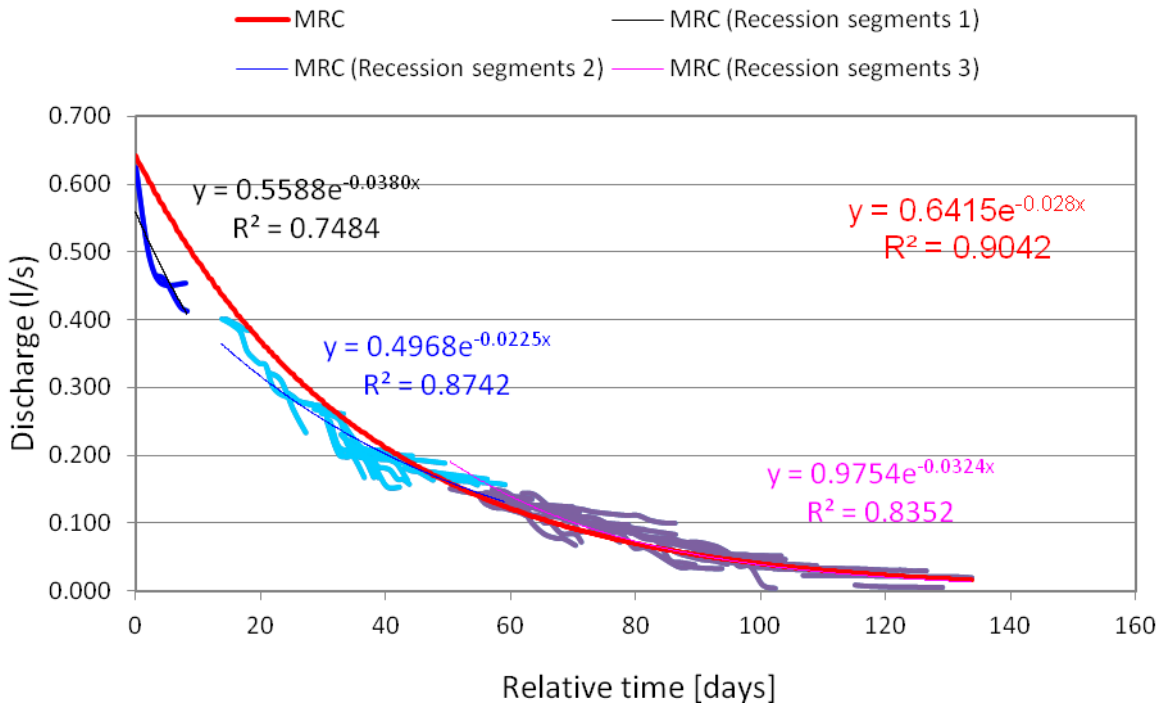


Figure 3. Separated MRCs of spring#10.

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.

1. **Title of the study**:

   Understanding Water Use Efficiency: A Field Based Research and Documentation of Best Practices on Water Use Efficiency and Conservation (**New Study**)

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

   PI (NIH) **:** Dr. V. C. Goyal, Sc F and Head, RCMU
   PI (IELO) **:** Mr Shawahiq Siddiqui, IELO

3. **Type of study**

   Internal (Jointly funded by NIH, Roorkee and IELO, Gurgaon)

4. **Date of start:** April 2012

5. **Scheduled date of completion:** March 2013

6. **Study Area:** Based on different geographical realities and water governance contexts, the proposed study is aimed to be carried out in the following tentative five states:

   a) Himachal Pradesh (Hill context)
   b) Maharashtra (Evolved water regulatory framework and industry context)
   c) Chhattisgarh (Central India and state rich in traditional water harvesting structures such as ponds, tanks)
   d) Uttar Pradesh (Water surplus state context)
   e) Meghalaya (North East and community water conservation practices and traditional water conservation knowledge context)
   f) Rajasthan (Water scarce region context)

7. **Study objectives**

   The overall aim and objective of the proposed project is to identify, explore and document best case studies and good practices on water use efficiency, conservation and harvesting across sectors such as agriculture, industry and domestic urban. The project also aims to throw important lessons for streamlining the concept of WUE by documenting and developing key policy and regulatory lessons from the existing case studies, best practices and examples on WUE. Specifically, the proposed study aims to:

   i. Identify, explore and understand best practices around WUE and water conservation across all water intensive sectors and undertake a comprehensive documentation of methods, processes, incentives, support, institutional mechanisms, participatory approaches and surrounding issues both positive and negative aspects.
   ii. Understand and document the reasons for successful stories and not so successful examples and impediments thereto
   iii. Develop an analytical policy brief based on the field based understanding of different facets of WUE and water conservation and policy or practices that have the potential for replication

8. **Methodology**

I. Extensive desk-based research for identifying and mapping good practices on WUE and conservation across the country, and in identified and proposed states for this study,
II. Field based research for locating, understanding and documenting good practices and case studies on WUE and water conservation,
III. Field based Consultation with local partner organizations (LPOs) and at the project/case study site for collection of data in all five target states,
IV. Deliberations with State and District level agencies and bare foot conservers of Water Resources,
   a. Brainstorming meetings and deliberations with water boards, regulators, municipal corporations, residential welfare societies and industrial houses,
   b. Personal interviews and soliciting information based upon standard questions for which a questionnaire will be developed,
   c. Comparative assessment of global practices on Water Use Efficiency in the countries with similar water scenario and competing developmental issues,
   d. Development of User Manual documenting good practices/success stories on Water Use Efficiency (Hindi and English),
   e. Development of a Policy Brief,
   f. Conducting a National Conference on Water Use Efficiency and Conservation.

9. **List of deliverables** (e.g. equipment, papers, reports, softwares, manuals, brochures, flyers, training programmes, users interaction workshops)
   i. Final Manual and Policy Brief (English and Hindi)- an indicative Table of Contents of the proposed Manual is given in Annexure-1.
   ii. Papers

10. **Study Benefits / Impact**

Measurable indicators	Expected achievements
New technologies/processes	This study will provide a comprehensive documentation on the best practices in water conservation and water use efficiency in India.
Improvement in skill	The document is expected to enhance awareness level of the users on the concepts of water use efficiency and legal provisions thereon.

1. **Title of the study**:

   Pilot Basin Studies in Identified Sites at Six RCs/CFMSs (**New Study**)

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

   Leader: Dr. V. C. Goyal, Sc F and Head, RCMU
   PI: One each from Divisions at the HQs and RCs/CFMSs

3. **Type of study**
   Internal (Jointly undertaken by NIH HQs and RCs/CFMSs)

3. **Date of start:** April 2012

4. **Scheduled date of completion:** March 2013

5. **Study Area:** The location of experimental basins is being carefully selected to address the existing water-related problems in critical areas.

6. **Study objectives**
   NIH proposes to undertake six Pilot IWRM Basin studies in different locations covering various agro-ecological regions in India. 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.

Annexure-1

Manual of Good Practices on Water Use Efficiency

Table of Contents (Indicative)

4.8 Water Treatment

4.9 Boiler and Steam Systems

4.10 Refrigeration (including Chilled Water)

4.11 Once-Through Cooling

4.12 Management and Employee Awareness Programs on water use efficiency

4.13 Industrial Site Specific Conservation

4.14 Cost-Benefit Analysis of effectiveness for Industrial Water efficient use practices

4.15 Incentives and award

5.0 Agricultural Water Use Efficiency

5.1 Good practices in Agricultural Irrigation Water Use and management

5.2 Irrigation Scheduling

5.3 Volumetric Measurement of Irrigation Water Use by designated government agencies at the state level

5.4 Efficient Management of Irrigation Canals

5.5 Drip/Micro-Irrigation System

5.6 Low Pressure Sprinkler Irrigation Systems

5.7 Linear Move Sprinkler Irrigation Systems

5.8 Tail-water Recovery and Reuse System

5.9 Traditional methods of water conservation, harvesting and farming

5.10 Traditional knowledge in water recharge and storage for irrigation

5.11 Cost benefit analysis in water efficiency in irrigation and role of government agencies involved

5.12 Incentives and award