AGENDA AND AGENDA NOTES

72nd MEETING OF THE TECHNICAL ADVISORY COMMITTEE (TAC) OF NIH

APPENDICES

(Vol.-II)

JUNE 3, 2019
AT 1500 HRS
2nd FLOOR (S), COMMITTEE ROOM
CWC, NEW DELHI

NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

APPENDIX – 72.2.1

MINUTES OF THE 71st MEETING OF TAC OF NIH

APPROVED MINUTES OF 71st MEETING OF TECHNICAL ADVISORY COMMITTEE OF NATIONAL INSTITUTE OF HYDROLOGY
Held on 23 April 2018 at New Delhi

The 71st meeting of the Technical Advisory Committee (TAC) of the National Institute of Hydrology, Roorkee was held in the Central Water Commission, New Delhi on 23 April 2018. The meeting was chaired by Er. S Masood Husain, Chairman, CWC. The list of the participants is given in Appendix -I.

At the outset, the Chairman in his opening remarks, welcomed the members and the invitees. He appreciated the works being carried out by NIH, and urged that the Institute should accord priority to conducting applied research, with focus on the latest development taking place in the water sector. After a round of introduction, general comments and suggestions were made by the TAC members on the working of NIH which are as follows:

Er Masood Husain, Chairman, CWC	1. R&D outcomes should be utilized by the intended users 2. Devise mechanism for review of completed studies and projects
Er N K Mathur, Member (D&R),CWC	1. Consult relevant standards for suitability of treated wastewater for use in MAR 2. Focus on lead research 3. Choose title of study carefully 4. NIH may consider a study on "Conjunctive use using NDVI" 5. Form a Working Group on "Impact of Climate Change on PMP", with members from NIH, CWC, and IMD/IITM
Dr Suhas P Wani ICRISAT, Hyderabad	1. Research should be judged by not just IF publications but also by adoption of research outcomes 2. More projects should be demand-driven
Dr Alok Sikka IWMI, New Delhi	1. Report of a completed study should mention where the study is leading to?

Dr V C Goyal, Member-Secretary, also welcomed the Chairman, members and invitees. A brief presentation on the organizational set up and activities of NIH was made for benefit of the new members. He then took up the agenda items.

ITEM NO. 71.2: Confirmation of the Minutes of 70th Meeting of TAC

The Member-Secretary informed that minutes of the 70th meeting of TAC, held on September 1, 2017, were circulated to all the members and invitees vide email dated September 22, 2017. Since no comments were received from the members, the Minutes were confirmed by the TAC.

ITEM NO. 71.3: Action Taken on Decisions/Recommendations in the Previous Meeting

The Member-Secretary presented a table showing comments and suggestions of the members during the previous meeting. He informed that the suggestions offered during the previous meeting have been noted for compliance, and actions initiated on development of regional methods for water availability analysis and design flood estimation, and studies on urban flooding. On the issue of developing content of the modules on 'Awareness on Water Issues' to be prepared for inclusion in the text books, Dr Sikka opined that NIH may examine available NCERT text books, and Prof Jayakumar advised to consult books prepared for UNICEF by CWRDM.

ITEM NO. 71.4: Status of the Work Programme for the Year 2017-18

The Member-Secretary briefed about the studies carried out by the Institute during the year 2017-2018. Members appreciated the number of publications brought out by the Institute and number of training/workshop/symposium organized by the Institute.

The following studies completed during 2017-18 were presented during the meeting:

1. Web enabled conjunctive use model for management of surface and ground water using concept of MAR and ASR (Dr N C Ghosh, GWH Division)
2. Modeling of Narmada basin using GWAVA model (Dr T Thomas, RC-Bhopal)
3. Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India (Dr Ashwini Ranade, SWH Division)

The Chairman suggested that the HI Division's study on "Rejuvenation of springs and spring-fed streams in Mid-Himalayan basin using spring sanctuary concept" should come out with clear methodology. On the study presented by Dr Thomas, the Chairman wanted to know what outcomes are expected from the modeling? Er N N Rai (CWC) desired that Interim Report of the EH Division's study on "Development of habitat suitability curves for the aquatic species of western Himalayan streams" be submitted to CWC for reference. TAC noted the status of work programme for the year 2017-18.

ITEM NO. 71.5: Report Proceedings of the Working Group and RCC Meetings

The Member-Secretary briefed about the 46th meeting of the Working Group of NIH, which was held at NIH, Roorkee, during 8-9 Feb., 2018, and the RCC meetings held at the different Regional Centres. During these meetings, the Working Group/RCC members reviewed the progress of studies for the year 2017-18 and recommended the proposed work programme for the year 2018-19.

The Chairman desired that salient recommendations of these meetings should be presented in bullet points for each Division/RC. TAC noted the proceedings of the Working Group and RCC meetings. TAC advised NIH to take up the following studies:

1. GIUH-based flood estimation,
2. Computation of consumptive water use by using NDVI
3. Impact of climate change on PMP- a group consisting of members from CWC, NIH and IITM may be formed.

ITEM NO. 71.6: Work Programme for the Year 2018-19

The Member-Secretary briefed about the proposed work programme of the Institute for the year 2018-19, which was discussed during the 46th Working Group meeting of NIH. The proposed work programme of the Regional Centres, as recommended by the respective RCCs, was also placed before the TAC.

TAC approved the work programme of the Institute for the year 2018-19 (Appendix-II).

ITEM NO. 71.7: Major projects and activities of national importance

A brief of the activities carried out under three major sponsored projects, viz. National Hydrology Project (NHP), Integrated Hydrological Studies for Upper Ganga Basin up to Rishikesh (NMSHE), and Neeranchal National Hydrology Project (NNWP), were presented. For the NNWP, Dr Wani advised that while developing DSS-Hydrology the work carried in Karnataka under Sujala Watershed Project may be consulted, which is based on the "LRI" concept.

ITEM NO. 71.8: Reporting Items

Details of the consultancy projects carried out by NIH during the year 2017-2018 were noted by the TAC. The Chairman suggested that the Scheduled Date of Completion of these projects should be mentioned. If the final report has been submitted, the project will be considered completed.

ITEM NO. 71.9: Additional items with permission of the Chair

I. **Data centre and web portal for COSMOS-India Network**

The TAC accorded permission for this activity with an advice that NIH should consider keeping a mirror site at some other location.

II. **Participation in an International Research Project**

TAC accorded permission for participation of Dr Sharad K Jain, Direcor, NIH, as Advisor in the research project entitled "Advancing frequency analysis of nonstationary hydrological extremes for reducing flood risk in a changing climate" funded by The Research Council of Norway for 3-year duration (2018-2021). Er Mathur (CWC) advised to explore if the data of Godavari or Krishna basins could be analyzed in this project.

III. **Organization of a HEPEX Workshop on Flood Forecasting at Roorkee, in 2019**

TAC concurred with the proposal of NIH to organize a Workshop on Flood Forecasting, jointly with HEPEX, to be held in Roorkee (India) in 2019. The Chairman advised to schedule the workshop on a convenient date by avoid conflicts with other major scientific meetings/events in India, US and Europe (e.g., AGU, AMS, EGU). Members from CWC expressed their interest in the workshop. NIH may explore funding support from CWC.

IV. **Signing of MoU with CSIR-NEERI, Nagpur**

TAC appreciated the forthcoming collaboration between NIH and CSIR-NEERI by signing a MOU, outlining the broad contours of collaboration. The MOU was signed in the presence of TAC members.

The meeting ended with a vote of thanks to the Chair.

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Appendix-I

LIST OF PARTICIPANTS IN THE 71st MEETING OF TAC OF NIH

1.	Er S Masood Husain, Chairman, CWC, New Delhi	In-chair
2.	Er N K Mathur, Member (D&R), CWC, New Delhi	Member
3.	Er N N Rai, CWC, New Delhi	Rep. CE (HSO)
4.	Dr Sharad K Jain, Director, NIH, Roorkee	Member
5.	Sh K. C. Nayak, Chairman, CGWB, New Delhi	Member
6.	Sh K V Singh, IMD, New Delhi	Rep. DDG(H)
7.	Dr S K Mishra, IIT Roorkee	Rep. IIT Roorkee
8.	Prof K V Jayakumar, NIT Warangal	Member
9.	Sh D K Singh, ICAR-IARI, New Delhi	Rep. Director, WTC
10.	Dr Suhas P Wani, ICRISAT, Hyderabad	Member
11.	Prof Rohit Goyal, MNIT, Jaipur	Member
12.	Sh H J Patel, SE CDO(Hydro) Gandhinagar	Member
13.	Sh Rajeev Baboota, NTPC, Faridabad	Member
14.	Dr Alok Sikka, IWMI, New Delhi	Member
15.	Dr V C Goyal, Sc. G, NIH, Roorkee	Member-Secretary

INVITEES

1. Director (R&D), MoWR, New Delhi
2. Dr Pawan Labhasetwar, NEERI, Nagpur
3. Dr N C Ghosh, Sc. G & Head, GWH Division, NIH, Roorkee
4. Dr Rakesh Kumar, Sc. G & Head, SWH Division, NIH, Roorkee
5. Dr C K Jain, Sc. G & Head, EH Division, NIH, Roorkee
6. Dr Sudhir Kumar, Sc. G & Head, HI Division, NIH, Roorkee
7. Dr Sanjay Jain, Sc. G & Head, WRS Division, NIH, Roorkee
8. Dr J V Tyagi, Sc. G, NIH, Roorkee
9. Dr M K Goel, Sc. G, NIH, Roorkee
10. Dr R P Pandey, Sc. G, NIH, Roorkee
11. Dr T Thomas, Sc. D, RC-Bhopal
12. Dr Ashwini A Ranade, Sc. C, NIH, Roorkee
13. Dr Pradeep Kumar, Sc. C, NIH, Roorkee
14. Dr Jyoti Patil, Sc. C, NIH, Roorkee

APPENDIX-72.4.1

WORK PROGRAMME OF THE DIVISIONS AT THE H.Q. AND RC/CFMS OF THE INSTITUTE FOR THE YEAR 2018–19

ENVIRONMENTAL HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. J V Tyagi	Scientist G & Head
2	Dr. M K Sharma	Scientist D
3	Dr. Rajesh Singh	Scientist C
4	Dr. Pradeep Kumar	Scientist C
5	Sh. Rajesh K. Nema	Scientist B
6	Ms. Anjali	Scientist B
7	Smt. Babita Sharma	RA
8	Smt. Bina Prasad	RA

Work Programme for the year 2018-19

S.No.	Study	Study Team	Duration/Status
Internal Studies			
1.	Development of Habitat Suitability Curves for the Aquatic Species of Western Himalayan Streams and Assessment of Environmental Flows	Pradeep Kumar (PI) C. K. Jain	3 Years (04/16-03/19) **Status:** In-progress
2.	Impact of Climate Change on Runoff and Sediment Yield for a Major Tributary of River Brahmaputra	Swapnali Barman (PI) J. V. Tyagi **Collaborator:** R.K. Bhattacharya (IITG)	3 Years (11/18-10/21) **Status:** In-progress
Sponsored Projects			
3.	Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin	M. K. Sharma (PI) Manohar Arora Pradeep Kumar Rajesh Singh D. S. Malik (GKU)	5 Years (04/16-03/21) **Sponsored by**: DST (NMSHE) **Project Cost**: Rs. 2.25 Crore **Status:** In-progress
4.	Ground Water Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District of Chhattisgarh State and Ameliorative Measures	M. K. Sharma (PI) Surjeet Singh Pradeep Kumar **Partner:** WRD, Raipur CGWB, Raipur	3 Years (09/17-08/20) **Sponsored by**: NHP-PDS **Project Cost**: Rs. 25.4 Lakh **Status:** In-progress
5.	Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures	Rajesh Singh (PI) Pradeep Kumar M. K. Sharma Sumant Kumar **Partner:** Irrigation Department, Punjab	3 Years (09/17-08/20) **Sponsored by**: NHP-PDS **Project Cost**: Rs. 65.6 Lakh **Status:** In-progress
6.	River Basin Planning and Reservoir Operations in Teesta, Rangit & Tributaries	Swapnali Barman (PI) M.K. Goel Deepti Rani, G. Arun **Partner:** WRD, Sikkim	3 Years (02/19-01/22) Sponsored by: NHP
Consultancy Projects			
7.	Study on Ash Disposal from Telangana STPP into Mine Void of Medapalli Open Cast Mines	C. K. Jain (PI) Sudhir Kumar Y. R. S. Rao S. D. Khobragade Anupma Sharma M. K. Sharma Pradeep Kumar	15 Months (04/16-06/17) **Sponsored by**: NTPC **Project Cost:** Rs. 54.4 Lakh **Status:** Completed
8.	Downstream Impacts of Water Withdrawal by TTPS from Brahmani River	Pradeep Kumar (PI) C. K. Jain M. K. Sharma	6 Months (05/18-11/18) **Sponsored by:** NTPC **Project Cost**: Rs. 20 Lakh **Status:** Draft Report submitted.

Training Programmes

SN	Topic	Duration	Place
1.	CPCB Sponsored Training Programme on Water Quality Monitoring of Surface, Ground, Waste Water / Effluent, Data Interpretation and Quality Assurance (Coordinator: Dr. C. K. Jain)	3 Days 11-13 Feb 2019	Roorkee

Study – 1 (Internal Study))

1. **Title of the Study:** Development of Habitat Suitability Curves for the Aquatic Species of Western Himalayan Streams and Assessment of Environmental Flows

2. **Study Group:**

Project Investigator Dr. Pradeep Kumar, Sc. 'C'
Project Co-investigator Dr. C. K. Jain, Sc. 'G'
Scientific/Technical Staff Nil

3. **Type of Study:** Internal

4. **Nature of Study:** Applied

5. **Date of start:** April 2016

6. **Scheduled date of completion:** March 2019

7. **Duration of the Study:** 3 Years

8. **Study Objectives:**

a) To compile the data/information on biotic parameters (abundance of aquatic species) and influencing abiotic parameters (water depth & velocity and water quality parameters: water temperature, pH, DO, BOD, turbidity etc.)
b) To identify the significant relationships between biotic and abiotic parameter and among the biotic parameters at selected locations
c) To establish the habitat suitability curves for aquatic species and habitat parameters
d) To assess environmental flows at the selected stretches in western Himalayan region

9. **Statement of the Problem:**

A large number of water resources projects (mostly hydropower schemes) in the western Himalaya are in different stages of development. These projects are altering the flow regime either due to storage or diversion of water. The river reach is deprived of its natural flows due to water diversion at control structure. There may be critical reaches in the river where altered flows are not able to sustain the ecosystem services existing prior to implementation of these types of projects. The developmental planning process in eco-sensitive and fragile Himalayan mountainous region should ensure that the biodiversity and ecological integrity of the aquatic and terrestrial ecosystems are protected and conserved. In this view, the environmental flow assessment has become imperative for the Himalayan rivers. However, due to lack of knowledge base on the biotic and abiotic interactions, the assessment of environmental flows in India has been mostly limited to hydrological and hydraulic methods. In this connection, the present study has been envisaged for developing the habitat suitability curves (relationships between abiotic and biotic parameters) for the aquatic species of the western Himalayan streams and assessing environmental flows using these curves.

10. **Approved Action Plan / Methodology:**

- Identification of data/ information on baseline biotic and abiotic parameters of western Himalayan streams and site selection
- Compilation of biotic and abiotic data/information

- Identification of relationships between biotic and abiotic parameters
- Development of habitat suitability curves
- Assessment of environmental flows using the developed habitat suitability curves
- Synthesis and report writing

11. Timeline

Work Element	1st year				2nd year				3rd year			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Identification of data/ information on baseline biotic and abiotic parameters of western Himalayan streams and site selection												
Compilation of biotic and abiotic data/information												
Identification of relationships between biotic and abiotic parameters												
Development of habitat suitability curves												
Assessment of environmental flows												
Synthesis and report writing												

12. Objectives and achievement during last one year:

Objectives	Achievements
a) To compile the data/information on biotic parameters (abundance of aquatic species) and influencing abiotic parameters (water depth & velocity and water quality parameters: water temperature, pH, DO, BOD, turbidity etc.)	The data related with biotic (density of phytoplanktons, zooplanktons, macroinvertebrates, fish) and abiotic parameters (water temperature, pH, DO, turbidity, Nitrates, Phosphatesetc.) of western Himalayan streams have been collected through different agencies. The baseline data of biotic and abiotic parameters have been compiled for 48 western Himalayan streams. Out of these 48 streams, three tributaries of Satluj river (Gambhar, Gamrola and Seer), three tributaries of Beas river (Sainj, Tirthan and Suketi) and two tributaries of Ravi river (Panjpula and Chaner) have been selected due to availability of detailed information.
b) To identify the significant relationships between biotic and abiotic parameter and among the biotic parameters at selected locations	The graphs between biotic and abiotic parameters and also among biotic parameters have been prepared. Different mathematical relationships are being tried to find out the significant relationships.
c) To establish the habitat suitability curves for aquatic species and habitat parameters	Habitat suitability curves between abiotic and biotic parameters have been developed for the keystone species of upper, middle and lower reaches of western Himalayan rivers.
d) To assess environmental flows at the selected stretches in western Himalayan region	Habitat simulation modelling is being carried out for three selected sites, one each in upper, middle and lower reaches of Upper Ganga river (a western Himalayan river).

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
No suggestions	-

14. Analysis & Results:

The data related with biotic (density of phytoplanktons, zooplanktons, macro invertebrates, fish) and abiotic parameters (water temperature, pH, DO, turbidity, Nitrates, Phosphates etc.) of western Himalayan streams have been collected through the existing literature. The average annual baseline data of biotic and abiotic parameters have been compiled for 48 western Himalayan streams. Out of these 48 streams, three tributaries of Satluj river (Gambhar, Gamrola and Seer), three tributaries of Beas river (Sainj, Tirthan and Suketi) and two tributaries of Ravi river (Panjpula and Chaner), average monthly data of biotic and abiotic parameters was also available. Hence, the analysis has been carried out in two parts: (i) using average annual data of 48 streams and (ii) using average monthly data of 8 streams. The correlogram between biotic and abiotic parameters and also among biotic parameters have been prepared and significant relationships have been identified. Different mathematical relationships (linear, polynomial, logarithmic, exponential etc.) have been tried to establish the relationships between abiotic and biotic parameters. Thus obtained relationships are not having very good coefficient of determination and therefore not properly representing the physical significance among these parameters. Hence, other statistical methods for developing the habitat suitability curves have been tried. Thus obtained habitat suitability curves for keystone species are being used for assessing environmental flows at three selected locations, one each in upper, middle and lower reaches of Upper Ganga river in western Himalayan region through habitat simulation modeling.

15. End Users / Beneficiaries of the Study: Policy makers and planners of State/Central Government Organizations dealing with water resources development

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: Nil

18. Lab facilities used during the study: Nil

19. Data procured or generated during the study:
Baseline information on the biotic and abiotic parameters of 48 western Himalayan streams (tributaries of Ravi, Beas, Satluj, Yamuna, Alaknanda and Bhairathi) has been procured from various sources.

20. Study Benefits / Impacts:

The outcome of the study will be valuable for the related departments for establishing more robust environmental flows through the improved knowledge base on habitat suitability curves for keystone species in the western Himalayan region.

21. Involvement of end users/beneficiaries: Nil

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

23. Shortcoming/Difficulties: Nil

24. Future Plan: Synthesis and report writing.

Study - 2 (Internal Study)

1. **Title of the Study:** Impact of Climate Change on Runoff and Sediment Yield for a Major Tributary of River Brahmaputra

2. **Study Group**

Project Investigator Dr. Swapnali Barman, Sc. 'C'
Co-Investigator Dr. J. V. Tyagi, Sc. 'G'
Collaborator Prof. R.K. Bhattacharya, IIT Guwahati

3. **Type of Study:** Internal

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

5. **Date of Start:** November 2018

6. **Scheduled date of Completion:** October 2021

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

8. **Study Objectives**

   i) To understand the impact of climate change on future rainfall, runoff and sediment yield of Puthimari River, a major tributary of river Brahmaputra
   ii) To compare and contrast physically based SWAT model and data-driven ANN model in predicting sediment contribution of Puthimari River to the main stream Brahmaputra.

9. **Statement of the Problem**

Climate change affects hydrology mainly through changes in precipitation, temperature and evaporation and it subsequently influences the temporal-spatial distributions of runoff and sediment, as well as the patterns of runoff and sediment transport. The Indian monsoon (june to September) rainfall is very crucial for the economic development, disaster management and hydrological planning for the country. The highly dynamic Brahmaputra river in South Asia carries one of the world's highest sediment yields. TheBrahmaputra flows through a seismically active region, which has the effect of causing it tocarry one of the highest sediment loads in the world.During its course, the river Brahmaputra is joined by important tributaries from the Himalayan ranges of Arunachhal Pradesh and Bhutan in the north and from the Khasi Hills, the Garo Hills, the Mikir Hills and the Patkai Hills in the south. The contribution of discharge and sediment from the north bank tributaries are more compared to those from the south bank tributaries. Hence it is important to study the tributaries which in turn effect the total sediment yield of the Brahmaputra River. For the present study, Puthimari river, a north bank tributary of Brahmaputra has beenchosen to study its impact on sediment yield to the Brahmaputra. As the basin is highly influenced by the monsoon rainfall, the climate change that results in variation in intensity of the monsoon, will affect both high and low flows leading to increased flooding and variability of available water both in space and time in the basin. A north bank tributary of the Brahmaputra River, the river Puthimari originates in the Tethyan Himalaya, a part of eastern Himalaya in Bhutan at an altitude of 3750 m (27°26´55´´N latitudes and 91°55´34´´ E lngitudes) and flows north to south through the Nalbari, Kamrup, Darrang, Baksa and Odalguri districts of Assam and debouches into the Brahmaputra river near Barsulia village, 7.6 km downstream from Hajo in Assam, India (26°14´52´´N latitudes and 91°26´55´´ E longitudes). The Puthimari River basin falls between

26°10´50´´N to 27°20´27´´ N and 91°25´57´´E to 91°56´12´´ E. The basin is extended in north-south direction from the high Tethiyan Himalayas to the flat plains of the River Brahmaputra in the state of Assam, India.

Runoff calculation of a river is essential owing to its effect on flood and erosion at the downstream. The actual physical processes that convert rainfall to runoff are both complex and highly variable. However, through the use of simplifying assumptions and empirical data, there are several mathematical models and equations that can simulate these processes and predict resultant runoff volumes and rates with acceptable accuracy. Being one of the major tributaries of the Brahmaputra, the river has major contribution towards discharge at its confluence with Brahmaputra. As such a rainfall-runoff model is proposed to study the impact of change in rainfall on the runoff of the river.

10. Approved Action Plan / Methodology

- Downloading of GCM data and rainfall trend analysis over the Puthimari River basin
- Downloading of satellite data and preparation of LULC maps
- Runoff and sediment analysis using ANN model
- Sediment yield modelling using SWAT
- Synthesis and Report writing

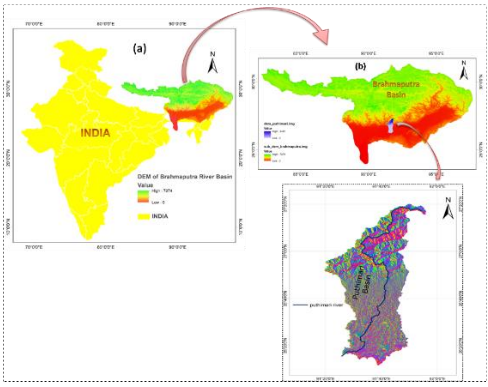
11. Timeline

S. No.	Activities	1st Year				2nd Year				3rd Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Downloading of GCM data and rainfall trend analysis over the Puthimari River basin												
3	Downloading of satellite data and preparation of LULC maps												
5	Runoff and sediment analysis using ANN model												
6	Sediment yield modelling using SWAT												
7	Report writing												

12. Objectives and Achievements during last twelve months:

The Puthimari river basin has been delineated using ASTER GDEM at a horizontal spatial resolution of 30 meters in ILWIS model. The steepest slope method has been used to determine the flow direction. According to the final result of ILWIS model, the perimeter of the catchment area is 498.15 km, area of the catchment is 3681.39 km^2, overall length of the drainage is 2567.93 km, drainage density is 0.69 km/km^2, length of longest flow path is 214.02 km, length of the Subansiri River is 214.02 km. According to Strahler ordering system the river belongs to 7th order and sinuosity is 1.728. The high drainage density of Puthimari catchment reflects that it is a highly dissected basin and has a relatively rapid hydrologic response to rainfall events compared to a low drainage density basin with slow hydrologic response.

Downscaled daily precipitation data with spatial resolution of 0.25 degrees (25 km x 25 km) have been downloaded for 11 different models under CMIP5 for RCP 4.5 and RCP 8.5. These 11 models are, *ACCESS1.0, BCC CSM1-1, CAN-ESM2, CCSM4, GFDL-CM3, INMCM4, IPSLCM5A-MR, MIROCC5, MPI ESM-MR, MRI-CGCM3 and NOR ESM1-M*. The trend analysis of precipitation is being performed for both historical and future projected data. Future rainfall trend is being performed for three different time frames viz., 2025-49, 2050-74 and 2075-99. Changes in climate over the Indian region, particularly the south-west monsoon, have a significant impact on water resources. Hence, changing rainfall pattern and its impact on runoff and sediment yield of a river remains a major climatic problem. In the present study, an attempt has been made to study the trend of monthly rainfall for both historical and future four time frames using non-parametric Mann-Kendall (MK) test and Sen's slope statistics. Trend detection for rainfall of the study area covered mainly of two steps; first to detect increasing or decreasing trend by MK test and second is the estimation of magnitude of trends using Sen's slope estimator.



Study area showing (a) India with Brahmaputra basin, (b) Brhamaputra and Puthimari basins and (c) The Puthimari basin

Landsat data of 30m resolution have been downloaded for the years 2006, 2012 and 2018 to study the land use/land cover changes that have been taken place in the Puthimari River basin.

13. Recommendations / Suggestions:

Recommendations / Suggestions	Actions taken
1. Instead of going for downscaling of GCM data, available downscaled data can be used for the study	Downscaled precipitation data available at 25km x 25km resolution have been downloaded for 11 models under CMIP5 for RCP4.5 and RCP8.5 respectively.
2. More time should be given to develop the SWAT model	Studies on applicability of SWAT model on sediment yield analysis is going on.
3. Thorough literature survey is to be made to understand the sediment characteristics of river Brahmaputra.	Literature survey is going on.

14. Analysis & Results: Elaborated as above at S.No. 12

15. End Users / Beneficiaries of the study: Water Resources Development Agencies

16. Deliverables: Technical Report & Research Papers

17. Major items of equipment procured: None

18. Lab facilities used during the study: None

19. Data procured or generated during the study:

- Daily downscaled precipitation data from 11 different models under CMIP5 for RCP 4.5 and RCP 8.5 at 0.25 degree resolution have been downloaded for the study area
- Landsat data have been downloaded for LULC change detection study

- Discharge and sediment data will be collected for the Puthimari River from Water Resources Department, Govt. of Assam

20. Study Benefits / Impacts:

The results of the study will assist the planners and managers dealing with water resources development projects.

21. Involvement of end users/beneficiaries: Nil

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

23. Shortcoming/Difficulties: No

24. Future Plan

A rainfall-runoff model will be developed to predict the future runoff of the river. Sediment yield modelling using SWAT and ANN model will be used to study the sediment yield contribution of Puthimari River to Brahmaputra.

Study - 3 (Sponsored Project)

1. **Title of the Study:** Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin

2. **Study Group:**

Project Investigator/Co-Project Investigator Dr. M. K. Sharma, Sc. 'D' Dr. Manohar Arora, Sc. 'D'
Co-Investigator Dr. Pradeep Kumar, Sc. 'C' Dr. Rajesh Singh, Sc 'C'
Scientific/Technical Staff Sri. Rakesh Goyal, Tech. Gr. I
Collaborating Agency Prof. D. S. Malik, Professor, GKU, Haridwar

3. **Type of Study:** Sponsored Project by DST, New Delhi, Budget: Rs 2.24 Crore

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

5. **Date of start:** April 2016

6. **Scheduled date of completion:** March 2021

7. **Duration of the Study:** 5 Years

8. **Study Objectives:**

i) To study ecology, biodiversity and water quality of Upper Ganga Basin
ii) To study in-stream reactions and sediment dynamics of Upper Ganga Basin
iii) To assess environmental flows in critical stretches of River Ganga

9. **Approved Action Plan/Methodology:**

i) Water quality assessment through comprehensive field and laboratory investigations.
ii) Monitoring point and non-point source pollution
iii) Adsorption characteristics through laboratory scale model studies.
iv) Kinetics and thermodynamics of adsorption process through experiment approaches.
v) Monitoring temporal abundance of different aquatic species at selected locations
vi) Monitoring aquatic habitat parameters (depth, velocity, slope, gradient, substrate, pH, conductance, water temperature, DO, BOD, COD, TDS, salinity, etc.) at selected locations
vii) Assessment of aquatic biodiversity: Phytoplankton, zooplankton, benthos and piscine fauna (distribution, species richness and abundance as per their habitat)
viii) Impact assessment of environmental flows in relation to productivity of River Ganga
ix) Estimating environmental flows in critical reaches

10. **Timeline:**

Activity	**1st year**		**2nd year**		**3rd year**		**4th year**		**5th year**	
	I	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**
Recruitment of Project Staff										
Equipment/software procurement										

Literature survey										
Field investigations										
Sample collection and analysis										
Adsorption characteristics										
Habitat characteristics										
Aquatic biodiversity										
Environmental flow estimations										
Report preparation										

11. Progress:

i) Water quality monitoring from fifteen identified sites is being carried out on monthly basis from September 2016. The analysis of hydro-chemical data indicated that water quality is satisfactory for bathing purpose except COD and TSS.

ii) High values of COD indicate anthropogenic pollution. TSS is high at all the locations and decreases from higher elevation to lower elevation because sediments gets deposited due to geomorphology of the river.

iii) Sediment samples from 15 sites have been collected and characterized for size distribution, pH, conductance and organic matter to study of in-stream reactions and sediment dynamics.

iv) Adsorption characteristics of sediments, kinetic and thermodynamic studies are hampering due to non-availability of facilities for trace element analysis. Attempts are being made to procure the equipment ICP-MS for trace element analysis.

v) Eight sampling zones are being monitored for temporal abundance of different aquatic species (Phytoplanktons, Zooplanktons, Macro-Benthos) on monthly basis. The analysis of collected data indicated that most common biotic species in the Upper Ganga Basin are phytoplanktons, zooplanktons, macro-benthos and fishes.

vi) Phytoplanktons are decreasing towards lower elevations while zooplanktons and macro-benthos are increasing at lower elevations.

vii) Monitoring aquatic habitat parameters (depth, velocity, slope, gradient, substrate, pH, EC, TDS, temperature, DO, BOD, COD, etc.) at eight selected zones on monthly basis for development of habitat suitability curves.

viii) Review of Environmental Flow Requirement (EFR) methodologies has been completed. Brief details of various hydro power projects under different stages of development in Upper Ganga Basin have been compiled for deciding the critical reaches for estimation of environmental flow requirement.

ix) Discharge data has been obtained from CWC and environmental flows recommendations will be based on the integration of hydrological, hydraulic and biological response data.

12. Research Outcome from the Project:

The present investigation will help in understanding the basic hydrology and associated water quality, ecology and biodiversity in Upper Ganga Basin for sustainable development of natural resources so that ecosystem stability is maintained. As a number of water resource projects are coming up in the Ganga Basin, the values of environmental flows in the critical reaches of the river will help in environmental clearance of the water resources projects.

Study - 4 (Sponsored Project)

1. **Title of the Study:** Groundwater Quality Assessment with special reference to Sulphate contamination in Bemetara District of Chhattisgarh State and ameliorative measures

2. **Study Group:**

NIH	WRD, Raipur	CGWB, NCCR, Raipur
Project Investigator: Dr. M. K. Sharma, Sc. 'D'	**Project Investigator:** Mr. A. K. Shukla, Sr. Geohydrologist	**Project Investigator:** Mr. A. K. Patre, Scientist D
Co-Investigator Dr. Surjeet Singh, Sc. 'E' Dr. Pradeep Kumar, Sc. 'C'	**Co-Investigator** Mr. Ashok Verma, Asstt. Geohydrologist Mr. P. C. Das, Asstt. Geohydrologist	-

3. **Type of Study:** Sponsored project by NHP (PDS), Budget: Rs 25,39,600/-

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

5. **Date of start:** 1 September, 2017

6. **Scheduled date of completion:** 31 August 2020

7. **Duration of the Study:** 3 Years

8. **Study Objectives:**

i) Groundwater quality monitoring in pre-monsoon (April-May) and post-monsoon (October-November) season at identified locations.
ii) To map degraded ground water quality zones and possible sources of pollution and identify specific parameters not conforming to drinking/ & irrigation water quality standards.
iii) To investigate the important geochemical processes responsible for the groundwater contamination.
iv) Modelling flow and transport of sulphate contamination using MODFLOW & MT3D
v) To suggest ameliorative measures to restore the quality and sustainable use of groundwater for drinking/ & irrigation purpose by investigating the hydro-geology of the area.
vi) Dissemination of knowledge and findings to field engineers/scientists and common people through preparation of manual, leaflets, booklets and by organizing workshops/training.

9. **Statement of the Problem:**

Groundwater is one of the vital resources, which meets the requirements of daily livelihood especially in rural areas of India. Growing demand of water in various sectors viz; agriculture, industrial and domestic sectors, has brought problems of over-exploitation of the groundwater resource, continuously declining groundwater levels, sea water ingress in coastal areas, and groundwater pollution in different parts of the country. Geo-environmental conditions have a marked influence on the groundwater quality. Hydrogeochemical studies relevant to the water quality explain the relationship of water chemistry to aquifer lithology. Such relationship would help not only to explain the origin and distribution of dissolved constituents but also to elucidate the factors controlling the groundwater chemistry. In the District Bemetara, Chhattisgarh, the Precambrian sedimentary province includes Chhattisgarh Super group of rocks of upper proterozoic age of marine origin. It mainly consists of arenaceous-argillaceouscalcareous rocks and dominated by Limestone, dolomite and calcareous shale. The weathered, cavernous and fractured part of the formation constitutes the aquifers in the area. The groundwater of Bemetara district is affected by sulphate contamination reported by Public Health Engineering Department, Durg. Berla block of the district has also the possibility of such type of sulphate contamination in ground water. Therefore, Bemetara district is selected for purpose driven study for sulphate contamination in ground water. The high concentration of sulphate in ground water is due to the dissolution of gypsum veins present within maniyari shale formation. Higher concentration of sulphate in ground water causes gastrointestinal irritation. A cost effective, economic viable and environmental friendly measure will be suggested for remediation of groundwater with special reference to sulphate contamination considering hydrogeology of the area.

10. Approved Action Plan/Methodology:

i) Literature survey on assessment of groundwater quality and issues in the region.
ii) Analysis of groundwater resources in the Bemetara district.
iii) Collection of existing meteorological and groundwater quality data of various locations of the Bemtara district and analysis.
iv) Collection of groundwater levels and lithological data from State Groundwater Department.
v) Hydrogeological characterization of the study area and establish specific linkages of groundwater quality with hydrogeology.
vi) Collection of groundwater samples from selected sources in pre-monsoon (April-May) and post-monsoon (October-November) season at identified locations.
vii) Analysis on flow and movement of groundwater.
viii) Analysis for physico-chemical parameters: pH, EC, TDS, Alkalinity, Hardness, Major Cations (Na, K, Ca, Mg), Major Anions (HCO_3, Cl, SO_4, NO_3), Minor Ions (F, PO_4,) and Toxic (Heavy) Metals: As, Cd, Cr, Pb, Cu, Ni, Fe, Zn, Mn in the collected water samples.
ix) Processing of hydro-chemical data for pre- and post-monsoon seasons as per BIS and WHO standards to examine the suitability of ground water for drinking purpose.
x) Ionic relationships will be developed and water types will be identified. Spatial distribution map will be prepared in the form of contour diagrams to identify degraded water quality zones, possible sources of pollution and specific parameters not conforming to drinking/ & irrigation water quality standards.
xi) Suitability of ground water for irrigation purpose will be assessed on the basis of total soluble salts, SAR and RSC. Classification of water will be made using Piper trilinear diagram, Chadha's diagram, U.S. Salinity Laboratory Classification.
xii) Processing of hydro-chemical data to understand the geochemical processes controlling the chemical composition of groundwater using Scatter Plots and Gibbs Plot.
xiii) MODFLOW & MT3D will used for modelling flow and transport of sulphate, the model will calibrated using data collected along space & time for a period of one year.
xiv) Suggesting ameliorative measures to control/ restore the groundwater quality for sustainable use by various users investigating site-specific measures considering contaminant transport, hydrogeology and system dynamics (flow-movement of groundwater, hydrogeology, managed aquifer recharge, withdrawal patterns, etc.).

11. Timeline:

Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
2017-18	-	-	Literature Survey	Field visit and Data Collection, Interim Report
2018-19	Field visit, Sampling, Data Collection and processing of the data	Sample Analysis and processing of the data	Field visit, Sampling, Data Collection, Analysis and processing	Analysis and processing of the data, Interim Report

2019-20	Field visit, Experiment, Data Collection, Analysis and processing	Analysis & Processing of the data	Modelling flow and transport of sulphate using MODFLOW & MT3D	Analysis & Processing of the data, Interim Report
2020-21	Analysis & Processing of data	Writing of Report	Writing of Report	-

12. Objectives and achievement during last twelve months:

Objectives	**Achievements**
Field visit, Sampling, Data Collection and processing of the data	A field visit was made during 07-11 Jan. 2019 for post-monsoon sampling and collected data
Sample Analysis and processing of the data	• Hydro-chemical analysis is in progress.
Organization of Training Course	• A 5-day Training Course on "Groundwater Quality Monitoring and Assessment" is scheduled to be organized during 3-7 June 2019 at NIH, Roorkee.

13. Recommendation / Suggestion:

Recommendation / Suggestion	**Action Taken**
• Dr. Bhishm Kumar suggested to colllect the samples from deep aquifers for quality aspect, which are being used by the public.	• Samples from deep aquifer collected in post-monsoon sampling.

14. Analysis & Results:

i) Carried out the extensive literature survey related to Sulphate contamination and prepared a manuscript for sending for publication in International Journal.
ii) Collected geological formation, SWL, Discharge, Drawdown, Transmissivity and Storativity data of 49 locations in Maniyari Shell Formation Region from CGWB, Raipur and is under processing.
iii) Hydro-chemical analysis of collected groundwater sample is under progress.

15. End Users / Beneficiaries of the Study: Policy makers and planners of Government of Chhattisgarh.

16. Deliverables: Technical report and research papers

17. Major items of equipment procured:

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

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

20. Study Benefits / Impacts:

For any scheme of water supply in an area, it is mandatory to have the status of water quality of the water resources being used for supply. An extensive survey of groundwater quality monitoring of district Bemetara will provide the knowledge about degraded ground water quality zones and possible sources of pollution and specific parameters not conforming to drinking/ & irrigation water quality standards, which will help the policy makers and society.

Further, present PDS will suggest ameliorative measures to restore the quality and sustainable use of groundwater for drinking and irrigation purpose by investigating the hydro-geology of the area.

21. **Involvement of end users / beneficiaries:** Water Resources Department (WRD), Government of Chhattisgarh, Raipur

22. **Specific linkage with Institution and /or end users / beneficiaries**: CGWB, Raipur and WRD, Raipur

23. **Shortcoming/Difficulties:** No

24. **Future Plan:**

- Processing of ground water data and water quality data.

Study – 5 (Sponsored Project)

1. **Title of the Study:** Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures

2. **Study Group:**

Lead Organization	**Project Investigator** Dr. Rajesh Singh, Sc. ‘C’
	Co-Investigator Dr. Pradeep Kumar, Sc. ‘C’ Dr. Mukesh K. Sharma, Sc. ‘D’ Er. Sumant Kumar, Sc. ‘C’
	Scientific/Technical Staff Sandeep Singh, RA Rakesh Goyal, Tech. Gr. I Meenakshi Rawat, JRF Prashant Kaushik, TA
Partner Organization	**Project Investigator** Er. Harminder Singh, Chief Engineer, Water Resources
	Co-Investigator Er. Narinder Kumar Jain, Director, WR&ED Dr. K. K. Kaushal, Sr. Hydrogeologist, WR&ED Mr. Sanjeev Bansal, Sr. Tech. Asst., WR&ED
Collaborators	Dr. S. P. Rai, Assoc. Professor, BHU, Varanasi Dr. Karrie A. Weber, Assoc. Professor, UNL, Lincoln Dr. Brijesh K. Yadav, IIT Roorkee Dr. Naseem Ahmed, IIT Roorkee

3. **Type of Study:** Sponsored project under NHP, Budget: Rs 65.6 lacs

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

5. **Date of start:** October 2017

6. **Scheduled date of completion:** September 2020

7. **Duration of the Study:** 3 Years

8. **Study Objectives:**

i) Spatial and temporal variation of water quality parameters and carcinogenic contaminants.
ii) Quantification of mutagenic potential (carcinogenicity) of water samples.
iii) Source identification of major contaminants in the study area and impact assessment on human health.
iv) Suggestions for possible remedial measures to reduce the impact of contaminants.
v) Dissemination of knowledge and findings to field engineers/scientists and common people through the preparation of manual, leaflets, booklets and by organizing workshops/training.

9. **Statement of the Problem:**

Punjab has been the subject of much skepticism in the last decade. It has previously been called the “grain bowl of the country”, but has recently adopted a new nickname, “the cancer bowl of the country”. The pride of holding the title “a state with maximum per capita income” came with the price of cancer due to unrestricted use of chemicals (pesticides, fertilizers, metals, polycyclic aromatic hydrocarbons, pharmaceutically active hydrocarbons, etc.) in the agricultural fields and industries. A train which connects the affected region with the nearby Bikaner city, which contains a cancer hospital, has been nicknamed Cancer Express. Thakur et a. (2015) analyzed trace metals, pesticides, and other relevant parameters in some major drains, water samples (surface as well as groundwater), fodder, vegetable, and blood samples, and concluded that these samples contained harmful contaminants in excess of desired levels. Intake of these contaminants through the water as well as food is leading to deleterious health effects such as gastrointestinal disorders, reproductive toxicity, neurotoxicity, renal toxicity, and carcinogenic manifestations (WHO, 2011). Another study conducted by Thakur et al. (2008) observed a higher prevalence of cancer cases and cancer-related deaths in the area. A year-long study entitled “An epidemiological study of cancer cases reported from villages of Talwandi Sabo block, district Bathinda, Punjab”, conducted by School of Public Health (SPH) at the Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, compared cancer incidents in the villages producing cotton with those producing rice and wheat, and found high cancer rates in the villages where pesticide usage was high. A recent hospital-based study for Punjab shows that out of the 1328 cancer cases in the state, 1230 cases were from the seven districts of Southern Punjab comprising Muktsar, Ferozepur, Bathinda, Faridkot, Fazilka, Moga & Mansa districts (Aggarwal et al., 2015). Considering the high cancer numbers and poor water quality described above, a comprehensive study of groundwater contaminants, especially carcinogens, is urgently required for the state of Punjab. The objectives of this study is to analyze the water quality of the area with an emphasis on carcinogenic chemicals, identifying their sources, and suggesting appropriate remedial measures.

10. Approved Action Plan/Methodology:

i) Upgradation of literature and data collection
ii) Delineation of villages and finalization of sampling locations
iii) Sampling & analysis of water samples
iv) Statistical analysis of the contaminant data and cancer incidences
v) Mutagenicity of water resources
vi) Contaminant remediation

11. Timeline:

S. No.	Activities	YEAR 1				YEAR 2				YEAR 3			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Hiring of manpower & training												
2	Purchase of equipment & consumables												
3	Upgrading literature and data collection												
4	Delineation of villages & finalization of sampling sites												
5	Collection and analysis of samples												
6	Statistical analysis of data and Carcinogenicity test												
7	Contaminant remediation												
8	Training & capacity building												
9	Scientific publications												
10	Final technical report												

12. Objectives and achievement during last twelve months:

Objectives	Achievements
Upgrading literature and data collection	• Data related to cancer cases has been collected from government agencies. The data has been converted from Punjabi to English for five districts and one is remaining. • The data related to type of cancer cases has been collected for Bathinda district and for remaining districts, will be collected by Apr 2019. • A review paper related to cancer contaminants in water resources is under progress. Moreover, a review on carcinogenic chemicals has been presented in the STIWM – 2018 conference.
Delineation of villages and finalization of sampling location	• The sampling locations for Bathinda, Mansa, Fazillka district has been finalized and the sampling locations for remaining districts (Muktsar, Ferozepur and Faridkot) are under progress.
Collection and analysis of samples	• Drinking water samples were collected during Feb. 2019 from Bathinda, Mansa, Fazilka district and analysis of organoleptic, major cations & anions, trace metals, and pesticides under progress.
Statistical analysis of data	• Health hazard quotient due to trace metals was computed for Bathinda district.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
Dr. Sharad Jain and Dr. Bhism Kumar suggested including the analysis of probable carcinogens in other routes of exposure that may lead to cancer.	The carcinogens will be analyzed in other routes of exposure after the analysis and interpretation work of drinking water is completed.

14. Analysis & Results:

Delineation of villages: The data of cancer-affected villages from the Punjab government was converted into English of year 2016, 2017, and 2018. Each district was divided into grid of 10x10 km. The cancer prone grids were identified and selected based on no. of cancer cases, per capita cancer cases, and no. of villages. Further, the village for sampling in a cancer prone grid was selected based on highest per capita cancer cases. Twenty samples for the analysis of physico-chemical, trace metal, pesticide and PAHs were collected from each district, 17 from cancer prone grids and 03 from minimal affected grids. In addition, samples were collected for the analysis of stable isotope (20 nos.) and tritium dating (05 nos.) from each district.

Results & Discussion: Analysis of samples collected in Feb. 2019 is under progress. However, the samples collected from 19 villages of Bathinda district in April 2018 was analysed for physical parameters, major anions and cations, and trace metals. All the analyzed organoleptic parameters except turbidity and TDS were well within the limits prescribed by BIS for drinking water. The turbidity was higher than the desirable limit for 57.8% of the samples, but was within the permissible limit for drinking water. The TDS content of 84.2% samples exceeded the desirable limit for drinking water, however only 10.5% exceed the permissible limit. In the study area, Ca, Mg and NH4 content in the analyzed drinking water samples exceeded the desirable limit for 5.3%, 63.1%, and 31.6% samples respectively. Similarly, Cl, SO4, and F content exceeded the desirable limit for drinking water in 10.5%, 47.4%, and 5.3% samples respectively. Also, the total hardness and total alkalinity exceeded the desirable limit in 84.2% and 52.6% samples, respectively.

Based on Hazards Quotients (HQ) computed through trace metal concentration, sample from Mandi Kalan was highly hazardous to human health, and samples from Mehma Sarja, Bambiha, Hanuman Chowk, Jai Singh Wala, Bhai Rupa, Dayalpur Mirza, Nasibpura, Central University of Punjab temporary campus, and Nathana were moderately hazardous, and rest were low in health hazard.

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

16. **Deliverables:** Technical report and research papers, First-hand information on water quality of the area related to carcinogenicity

17. **Major items of equipment procured:** i) Multiparameter Ion Analyzer ii) Syringe Pump iii) Geochemistry Software

18. **Lab facilities used during the study:** Water Quality and Isotope Lab (NIH) / IIC (IITR)

19. **Data procured or generated during the study:** Water quality data of the area

20. **Study Benefits / Impacts:**

The outcome of the project will be beneficial for the concerned departments in a sense that it will provide the first-hand information on the water quality of the area related to carcinogenicity. This will also lead in preparing a protocol for monitoring the carcinogenicity of water and will be helpful for the monitoring agencies. The project will also suggest the remedial measure for providing safe water to the habitation, which can be implemented by concerned state government agencies.

21. **Involvement of end users/beneficiaries:** Water Resources & Environment Directorate, Punjab and Local people

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

23. **Shortcoming/Difficulties:** NA

24. **Future Plan:**

i) Delineation of sampling sites for Muktsar, Ferozepur, and Faridkot districts.
ii) Collection and analysis of samples.
iii) Statistical analysis of data and carcinogenicity test.

Study - 1 (Internal Study – New)

1. **Title of the Study:** Water quality assessment of Haridwar District

2. **Study Group**

Project Investigator Er. Rajesh K. Nema, Sc. B
Co-Investigators Dr. Rajesh Singh, Sc. C Dr. J. V. Tyagi, Sc. 'G' Dr. Pradeep Kumar, Sc. C

3. **Type of Study:** Internal

4. Nature of Study: Applied Research

5. Date of Start: May 2019

6. Scheduled date of Completion: April 2022

7. Duration of the Study: 3 years

8. Study Objectives

(i) Spatial variability determination of groundwater quality
(ii) Statistical analysis and water quality indexing for different designated uses namely drinking, irrigation, and aquatic life

9. Statement of the Problem

Water of sound quality is the key for vital socio-economic functions on Earth. Most users of water depend on adequate levels of water quality. When these levels are not met, these water users must either pay an additional cost for water treatment or incur at least increased risks of damage or loss. As populations and economies grow, more pollutants are generated and degradation of water resources has become one of the most pressing global concerns currently facing mankind. Increasingly, the major efforts and costs involved in water management are devoted to water quality protection and management. Conflicts among various users of water are increasingly over issues involving water quality as well as water quantity. Evidently, there is a need for effective management efforts, where one possible action is to focus on minimizing pollutant load from pollutant-producing areas to water resource areas.

Generally, water quality is the process to determine the chemical, physical and biological characteristics of water resources and identifying the source of any possible pollution or contamination, which might cause degradation of the water quality. Chemical weathering of the rocks leads to introduction of dissolved solids in the water resources and conversely water chemistry provides information on chemical erosion processes (Chetelat et al., 2008). Chemical weathering is a chemical reaction; therefore it requires a "substrate" and "reacting agents" for it to occur. The substrates on the earth surface are the minerals in rocks and the reacting agents are acids, such as, carbonic acid (HCO^-_3 derived from dissolution of CO_2); sulfuric acid (H_2SO_4 derived from pyrite oxidative weathering and a number of organic acids (oxalic, acetic and humic), which liberate protons to weather the minerals. In addition to these acids, H_2O also acts an agent in dissolving evaporite minerals. In addition, the quality of water resources is also affected by the anthropogenic activities resulting in the degraded water quality. In case of groundwater pollutants reaching the aquifer results in various reactions and most of the times enhances the microbial reactions leading to release of harmful contaminants like arsenic, uranium, fluoride etc. from the aquifer minerals making the water unfit for

consumption. These type of changes occur over a prolonged time scale and hence, continuous monitoring of the water resources helps in avoiding the havoc that may happen due to consumption of contaminated water.
Our main interest is to analyze the water sample for organoleptic parameters, major ions, trace metals, and pesticides to understand the suitability of water for different usage and to understand the weathering processes controlling the water quality.

10. Methodology

a. Collection of groundwater samples during pre and post monsoon from selected locations of Haridwar district.
b. Analysis of water samples for organoleptic parameters, major ions, trace metals, and pesticides.
c. Processing the data to understand the contamination of water and suitability of various designated use.

11. Work schedule / Timeline

Sr. No.	Major Activities	2019-20			2020-21				2021-22			
		2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
1	Field Investigation and sampling plan											
2	Sample Collection and Analysis											
3	Data Processing and Interpretation											
4	Interim Report											
5	Final Report											

12. Cost estimate: Rs. 17,10,000 (NIH Internal Fund)

Sr. No.	Sub-Head	I Year	II Year	III Year	Total
1	Travelling expenditure	1 50 000	1 50 000	1 00 000	**4 00 000**
2	Infrastructure / Equipment / Consumable	7 00 000	2 00 000	2 00 000	**11 00 000**
3	Experimental charges	20 000	20 000	20 000	**60 000**
4	Misc. Expenditure	50 000	50 000	50 000	**1 50 000**
5	Grand Total	9 20 000	4 20 000	3 70 000	**17 10 000**

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

- Travelling expenditure: For visit to study area, attending conferences, data collection, surveys etc.
- Equipment/Consumables: Purcahse of Ion selective electrodes, chemicals, glasswares, plastics, etc.
- Experimental charges: Towards analysis of samples in outside laboratories

13. Research outcome from the project:

a. Geo-spatial data base of water quality
b. Water quality index for various designated use

c. Technical report and papers

14. End Users / Beneficiaries of the study: Uttarakhand Jal Sansthan, Deptt. of Irrigation, Uttarakhand

GROUND WATER HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Er. C.P. Kumar	Scientist G & Head
2	Dr. Anupma Sharma	Scientist E
3	Dr. Surjeet Singh	Scientist E
4	Er. Sumant Kumar	Scientist C
5	Mrs. Suman Gurjar	Scientist C
6	Dr. Gopal Krishan	Scientist C
7	Sh. Nitesh Patidar	Scientist B
8	Mrs. Anju Choudhary	SRA
9	Sri Sanjay Mittal	SRA
10	Sri S.L. Srivastava	SRA
11	Sri Ram Chandra	RA

NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हि ष्ठा मयोभुवः

Approved Work Programme for the year 2018-19

S. No.	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/NIH/15-18	Peya Jal Suraksha - Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply	N.C. Ghosh (Lead), B. Chakravorty, Y.R.S. Rao, Anupma Sharma, Surjeet Singh, Sumant Kumar, Gopal Krishan, Suman Gurjar, Anju Chaudhary, Sanjay Mittal, Ram Chander	2-1/2 year (11/15 – 4/18) Extended by one year. **Status: In progress**	Sponsored by MoWR, RD & GR under Plan Fund
2. NIH/GWD/BGS/16-20	Ground water Fluctuation and Conductivity Monitoring in Punjab - New evidence of Groundwater Dynamics in Punjab from High Frequency Groundwater Level and Salinity Measurements	**From : NIH, Roorkee** Gopal Krishan (PI), Surjeet Singh, C. P. Kumar, N.C. Ghosh **From : BGS, UK** Dr. Dan Lapworth (PI) Prof. Alan MacDonald	3 years (01/16-11/20) **Status: In progress**	Sponsored by BGS, UK
3. NIH/GWD/NMSHE/16-20	Study of River - Aquifer Interactions and Groundwater Potential at Selected Sites in the Upper Ganga Basin up to Dabrani	Surjeet Singh (PI), N.C. Ghosh, R. J. Thayyen, Sudhir Kumar, Manohar Arora, Gopal Krishan	5 years (01/16 – 12/20) **Status: In progress**	Sponsored by DST under NMSHE SP-8
4. NIH/GWD/NIH/16-19	Grey Water to Blue Water – Natural Treatment Techniques for Transforming Wastewater into Sustainable Useable Water	N.C. Ghosh (Lead), Anupma Sharma, Surjeet Singh, Sumant Kumar, Suman Gurjar, Anju Chaudhary, Sanjay Mittal, Ram Chander Partners: IIT Bombay UJS, Dehradun	3 years (11/16-10/19) **Status: In hold**	Sponsored by NWM, MoWR, RD & GR
5. NIH/GWD/DST/18-20	Future Secular Changes and Remediation of Groundwater Arsenic in the Ganga River Basin -FAR GANGA	**NIH-Team:** N. C. Ghosh (India Lead), Surjeet Singh, Sumant Kumar, Gopal Krishan, Suman Gurjar **Other India partners:** IIT Roorkee, IIT Kharagpur, Mahavir Cancer Sansthan, Patna. **UK- Partners:** Univ. of Manchester, BGS, Salford University, Univ. of Birmingham	**3 years** (01/18 – 12/20) **Status : In progress**	DST-Newton Bhabha - NERC- India-UK Water Quality Research Programme
6. NIH/GWD/DST/18-20	Impact of Rainwater Harvesting on Groundwater Quality in India with Specific Reference to Fluoride and Micro-pollutants.	**NIH-Team:** Anupma Sharma (Indian Lead), Sumant Kumar, Gopal Krishan, Suman Gurjar, M. K. Sharma **Other Indian partners:** IIT Ropar, IIT Jodhpur. **UK Partner:** Cranfield University School of Water, Energy and Environment	**3 years** (01/18 – 12/20) **Status : In progress**	DST-Newton Bhabha- NERC- India-UK Water Quality Research Programme

		Project Partners: Wells for India and Excellent Development, UK based NGOs together with their Indian offices and local NGO partners in Rajasthan		
7. NIH/GWHD/ PDS/18-22	Ganges Aquifer Management in the Context of Monsoon Runoff Conservation for Sustainable River Ecosystem Services - A Pilot study	Surjeet Singh (PI), N.C. Ghosh, Sudhir Kumar, C. P. Kumar, Suman Gurjar, Gopal Krishan **Implementing Agency:** GW Deptt., Govt. of UP	04 Years (03/18-02/22) **Status: In progress**	Sponsored by NHP under PDS
8. NIH/GWHD/ PDS/18-20	Assessment of Impacts of Groundwater Salinity on Regional Groundwater Resources, Current and Future Situation in Mewat, Haryana – Possible Remedy and Resilience Building Measures	NIH, Roorkee, India Gopal Krishan (PI), N. C. Ghosh, Surjeet Singh, C. P. Kumar, S. K. Verma **IIT-Roorkee** M. L. Kansal, Brijesh Yadav (PI) **Sehgal Foundation, Gurgaon** Lalit Mohan Sharma	03 years (01/18-12/21) **Status : In progress**	Sponsored by NHP under PDS
9. NIH/GWHD/ PDS/18-20	Hydro-geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin	Sumant Kumar (PI), N.C. Ghosh, Sudhir Kumar, Rajesh Singh, Gopal Krishan, Anju Chaudhary, Ram Chander Partner Organization **MWRD, Bihar** Collaborator **Brijesh Yadav, IIT Roorkee N.S. Maurya, NIT Patna**	03 years 01/18-12/20 **Status : In progress**	Sponsored by NHP under PDS
10. NIH/GWD/PD S/18-20	Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin upto Delhi	**NIH Team:** Anupma Sharma (PI), N. C. Ghosh, Sanjay K. Jain, Archana Sarkar, M. K. Sharma, L. N. Thakural, Sumant Kumar, Suman Gurjar, Vishal Singh, Nitesh Patidar **Partner Organization:** Sanjeev Bansal (C.E., IWRD Haryana), Amod Kumar (Tech. Coord., GWD U.P), S.E. YBO, CWC New Delhi	04 years 04/18-03/22 **Status : In progress**	Special Project under "Centre of Excellence" (NHP)
11. NIH/GWD/NI H/18-19	Application for Conjunctive Use Management of SW & GW in Saryu Nahar Pariyojna, U.P. using "Strategic Basin Planning Model for Ganga River Basin"	Suman Gurjar (PI), Jyoti Patil (Co-PI), N .C. Ghosh, Anupma Sharma, Sumant Kumar, Surjeet Singh	1 Year (04/18 – 3/19) **Status: Dropped** due to various issues in customization, after many	Internal Funding

			tries, the designed system is not allowing the level of customization we need to do for proposed study and too much dependency on the consultant team for each customization.	
Other R & D Projects				
12.	DSS planning & Management in Selected States	Anupma Sharma + Team		NHP
13.	Development of Groundwater Model for Integrated Hydrologic Model	Anupma Sharma, Surjeet Singh, Suman Gurjar, Sumant Kumar		CEHM, NHP
Consultancy Projects				
1. CS-146/2018-18/GWH	Investigation of Physical Groundwater Table and Ascertaining its Fluctuation and Trend in Stretch from Chainage 59+600 m to 67+300 m in Rewari to Dadri of CTP-14 Package of Western Dedicated Freight Corridor Project	N. C. Ghosh (PI)	06 Months (05/18-10/18) **Status: Completed**	L & T India, Ltd.
2.	Water Availability Study based on Hydrological Investigations and Modeling of Upper Hindon Basin	Anupma Sharma (PI)	02 Months (04/19-05/19) **Status: In progress**	Irrigation Deptt., Saharanpur

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

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

Project duration: 30 months (November 2015 – April 2019), extended by nine months up to December, 2019

Type of study: Sponsored by MoWR, RD & GR, GoI Under NIH's Plan Fund

Nature of study: Demonstration and applied research

Methodology

Six pilot demonstration schemes in 5 states, viz. one in Uttarakhand (Laksar along Solani river), two in Uttar Pradesh (Mathura and Agra along the Yamuna river), one in Jharkhand (Sahebganj along Ganga river), one in Bihar (Ara along Ganga river), and one in Andhra Pradesh (Visakhapattnam area) were planned to develop. Respective State Jal Sansthan/PHED/Jal Nigam was included as the collaborating partner for the schemes. HTWD, Germany was associated as scientific and technical adviser. The roles of State Jal Sansthan/PHED/Jal Nigam are to extend administrative and logistic supports in the field including identification of sites and providing required land for the scheme and electrical facilities for installation of tube wells and O & M of the pumps.

Deliverables

Schemes demonstrating effectiveness of 'Riverbank Filtration' technique for sustainable drinking water supply in different hydrogeological settings, river hydraulic and groundwater conditions are the planned deliverables and these schemes after thorough investigations will be handed over to the respective state 'Jal Sansthan' to use them as the guiding scheme towards attaining drinking water security, particularly in rural areas.

Progress

Based on the progress made so far on the study, a detailed report (Part-1) has been prepared and the report is available on NIH's website: **nihroorkee@gov.in** (click: old website, in the old website click, 'Institutional Digital Repository')

Location-wise progress is given below:

(i) Laksar Site, Uttarakhand

The RBF site explored and installed tube well at Kuan Khera village in Laksar, UK in the year 2016 was abandoned because of water quality problem of geogenic origin and also due to its damage by bank erosion and threat of riverbank shifting.

(ii) Mathura and Agra Sites

Phase-I that dealt with exploratory drilling, development and installation of production tube wells both at Mathura near Gokul barrage and Agra near Agra Water Works were completed through U. P. Jal Nigam, Agra as deposit work. Phase-II that deals with installation of submersible pumps, construction of pumping plants, pump house, stand post, etc. for both the sites is in progress. The estimated cost for Phase-II of both the sites is Rs. 34.72 lakh including all taxes. The works of Phase-II are in progress.

(iii) Ara site in Bihar

Of late (16-18 Feb., 2019), PHED, Govt. of Bihar has carried out the drilling, lowering and development of the bank filtration tube well in the premise of the temple, identified as the location for RBF (latitude - 25^{0}41' 0.00" N and longitude - 84^{0}43' 34.94"E) in Barhara village of Ara district, Bihar. The site is located about 50 m away from the Ganga river water line. Resistivity survey of the location was carried out before the drilling work.

Figure : RBF site in the temple premise of Bahara village, Ara district

Photographs of well development: (a) Exploratory drilling, (b) Air compressing for well development, (c) a stage of well development, and (d) water sample collection from the Ganga river for analysis.

Most of the villages in Ara district along the Ganga river have groundwater arsenic contamination and villagers have no organized safe drinking water supply. The aquifer at a depth below 30/35 m has generally been reported as arsenic affected. The pilot RBF scheme at Ara has been planned to demonstrate, if it could succeed as an alternate to provide safe drinking water supply in the rural arsenic affected areas, then it would be a success story.

(iv) **Vishakapattanam, A.P.**

A site along the Varaha river located in between Kakinada and Vishakapattnam city was selected in consultation with A.P. RWS & S, Govt. of Andhra Pradesh for exploratory drilling and installation of RBF well. The Varaha river is a seasonal type river at the upstream with subsurface flow below the riverbed; however, as it flows downstream, the river possesses the characteristics of perennial river. Most of the villages along and around the downstream stretches of the Varaha river have the problem of groundwater salinity, TDS (> 1000 mg/L) and most of the villages don't have organized drinking water supply system. As a result, some of the villages are forced to drink dug wells based groundwater, which has also high TDS. The site located in the village named Vommavaram in S. Rayavarammandal with latitude 17^{0}27'20.1" N and longitude 82^{0}47'19.2" E along the right bank of the Varaha river has been selected for exploratory drilling and tube well installation through RWS & S, Govt. of Andhra Pradesh.

Geophysical survey, water quality analysis of both river and groundwater have been carried out. After geophysical survey and water quality analysis, of late, drilling and lowering of tube well have been carried out. Well development and pumping test are likely to be done.

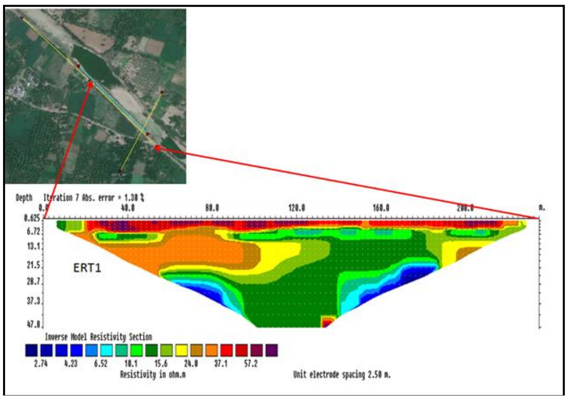


Figure showing result of geophysical survey for a section, and a snapshot of infield water quality analysis.

Phographs showing stages of drilling work in progress

(v) Sahebganj, Jharkhand

The RBF in Sahebganj (Jharkhand) has been dropped, because of no response from the PHED, Govt. of Jharkhand despite physical interaction and reminders.

Phase-1 of all the explored sites has been completed. Phase-II, comprising works of installation of submersible pumps, construction of pumping plants, pump house, stand post, etc. is to be carried out. For Mathura and Agra site, the works of Phase-II are in progress. For other two sites, Ara and Visakhapatnam, the works for Phase-II are also initiated.

Hence, WGMs nine (9) months extension is sought from Working Group for completing the project in all respects.

2. PROJECT REFERENCE CODE: NIH/GWD/BGS/17-20

Title of the study	: **Groundwater Fluctuations and Conductivity Monitoring in Punjab - New Evidence of Groundwater Dynamics in Punjab from High Frequency Groundwater Level and Salinity Measurements**

Type of study	**:**	Sponsored**,** BGS, UK.
Date of start (DOS)	**:**	December 2017
Scheduled date of completion	**:**	November 2020
Location	**:**	Bist-Doab Punjab

Study objectives:

1. To characterise multi-year variability in groundwater level and SEC using high frequency groundwater measurements within nested shallow and deep piezometers
2. To collate new evidence on recharge processes, groundwater quality, groundwater residence times, and connectivity of the layered aquifer systems and surface water by repeated sampling of shallow and deep piezometers using a suite of environmental tracers
3. To prepare a status report on groundwater issues in Punjab

Statement of the problem:

Management of groundwater resources in the Indian context is an extremely complex proposition and any strategy for scientific management of groundwater resources should involve a combination of supply side and demand side measures depending on the regional setting. In view of the marked difference in stage of groundwater in these areas, there is a need to critically analyze the underlying factors responsible for the imbalances in terms of technical and socio-economic considerations. These should also be taken for consideration while formulating any comprehensive water resources management initiatives for the country. There is urgent need for coordinated efforts by various researchers for evolving implementable plan for effective management of this precious natural resource. Higher rate of withdrawals are observed in the state of Punjab where the annual rate of groundwater level decline is increasing by about 80% and projected to fall by about 21 meters in 2/3rd area of central Punjab during next 2 decades. The large drop in groundwater levels can be due to several reasons like high withdrawals, low-recharge, low-transmissivity, poor conditions of surface water recharge source conditions etc. In addition to declining water level, the quality of groundwater is also a concern in Punjab. Considering these facts, National Institute of Hydrology, Roorkee, is carrying out a research project jointly with BGS, UK duly approved by Ministry of Water Resources, RD and GR during 2017-2020 to get a high frequency water level and conductivity data along with the analysis of water samples for a suite of tracers.

Recent evidence shows that water levels in groundwater monitoring boreholes in Bist-Doab Punjab comprising of Nawanshahr (new name SBS Nagar), Jalandhar and Kapurthala districts over short (hours, days) and longer (weeks, months) periods are driven principally by extractions, rather than as a hydrological response to groundwater recharge and flow. The data analysis carried out demonstrates (i) the limitations of using groundwater levels in piezometers to indicate groundwater recharge, as conventionally applied in groundwater resources management, and (ii) conditions under which groundwater levels respond primarily to changes in the mass of terrestrial water storage. Surface water loading effects are dominant, the conventional assumption that groundwater levels indicate the status of groundwater storage is invalidated. Strategies for expansion of regional or national groundwater monitoring programmes (spatially or in depth) should account for the scale and styles of loading effects. For getting aquifer specific measurements for shorter screened intervals of conductivity and water level will provide some conclusive results for proper water resource management of this important region of the Punjab state.

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

Methodology:

In this study, groundwater level and conductivity data are monitored and high resolution field based observations are collected. For this, the loggers for conductivity have been installed in 4 shallow piezometers of PWRED, Chandigarh at Saroya (Kandi region), Bhogpur, Kapurthala and Sultanpur Lodhi and water loggers are installed in the Saroya, Bhogpur and Sultanpur Lodhi in the month of May, 2018 (Fig. 1).

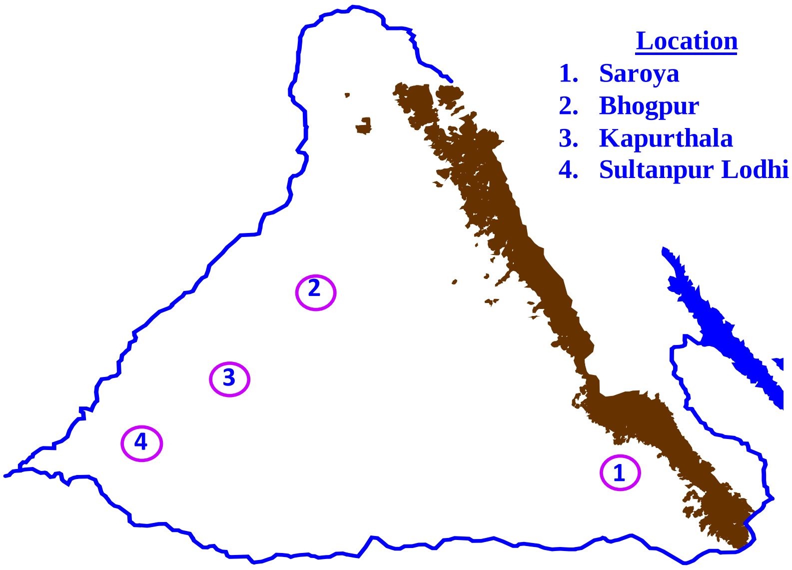


Fig. 1. Study area, Bist Doab, Punjab

These loggers are installed considering the physiography, geomorphology and hydro-geological conditions of the area.

(i) *Saroya*: Saroya is in Siwalik area where sandstones constitute good water bearing zones. These areas require special attention to mitigate the water needs of the people. Groundwater draft is 80%. In a Kandi tract of the state, low height dams across choes are constructed for water harvesting.

(ii) *Bhogpur* – where farmers have adopted paddy cultivation due to profitability and incentives from the Government leading to extensive development of groundwater. There is an urgent need to change the cropping pattern in these areas and to adopt cultivation of those crops which require less irrigation. Groundwater draft is 80-90%.

(iii) *Kapurthala* - which is in the city area and stress on pumping of groundwater is increasing to meet the ever-increasing demand of water for domestic and industrial uses. This has resulted in decline of water levels at faster rates as compared to adjoining rural areas. This over-exploitation of groundwater has caused formation of groundwater troughs in the central part of the cities resulting in increased energy consumption. In order to arrest the water table decline, either canal water should be supplied to the thickly populated areas or well fields may be developed in the outskirts of the cities and water be supplied through pipeline. Groundwater draft is 90%.

(iv) *Sultanpur Lodhi* - low lying area and might experience rise in water levels. This area is near to Harike wetlands. Groundwater draft is 60-70%.

Water level responses were consistent at 4 sites, initial observations are as below:

- Groundwater levels are impacted by a range of processes which operate at a range of different frequencies: pumping for irrigation and domestic use, groundwater recharge and earth tides.
- Groundwater level response in all sites is heavily impacted by pumping. This is most evident

during monsoon when Kharif crop is irrigated by groundwater and lowest/deepest groundwater levels were found.

- These observations are simultaneously observed in deep and shallow depths.
- Sharp rise in groundwater levels, likely due to changes in pumping, are observed at the end of monsoon in all sites.
- Water levels recover during pre-monsoon period when pumping is minimum. There is also sub-monthly variation observed in the groundwater levels which may be due to number of factors: pumping schedules and possibly recharge response to episodic rainfall.
- Initial inferences are that the mechanical loading effects are minimal in Punjab compared to other settings in India. This is likely due to the more rigid structural architecture of this region of north-west India, the extensive kankar deposits may be partly responsible for this phenomenon.

A workshop was organized at University College London, London on the subject: 'Groundwater resources monitoring in deep basins and delta regions: evidence and implications of aquifer poroelastic behaviour' during Feb 12-15, 2019 in which observations from this study were presented. New loggers provided by BGS, UK will be installed in these/selected piezometers shortly.

Action plan:

Year	Dec. 2017 to Nov. 2020	Remark
Dec. 2017 to Nov. 2020	Literature review on available groundwater studies including water table, water quality and other hydrogeological aspects in Punjab Monitoring of water level and conductivity fluctuations in Bist-Doab, Punjab Water sampling and analysis for isotopes Prepare a status report on groundwater issues in Punjab Presentation of work progress in a workshop/review meeting under the project	Report preparation as per activity schedule

Study Benefits /Impact:

- An overview report on groundwater status in Punjab
- Suggesting some water resources management plans
- Research publication in high impact journals
- Upload of results on NIH website

Specific linkages with Institutions: BGS, UK

Activity Schedule (Quarter Wise From Dec. 2017 To Nov. 2020)

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Downloading data	♦		♦		♦		♦		♦			♦
Sample collection and analysis			♦			♦			♦			
Collection of data from various agencies (NIH)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
First Draft (NIH-BGS)				♦								
Second Draft Report/Technical publication (NIH-BGS)								♦				
Final Report/Publication(NIH-BGS)											♦	♦

Progress

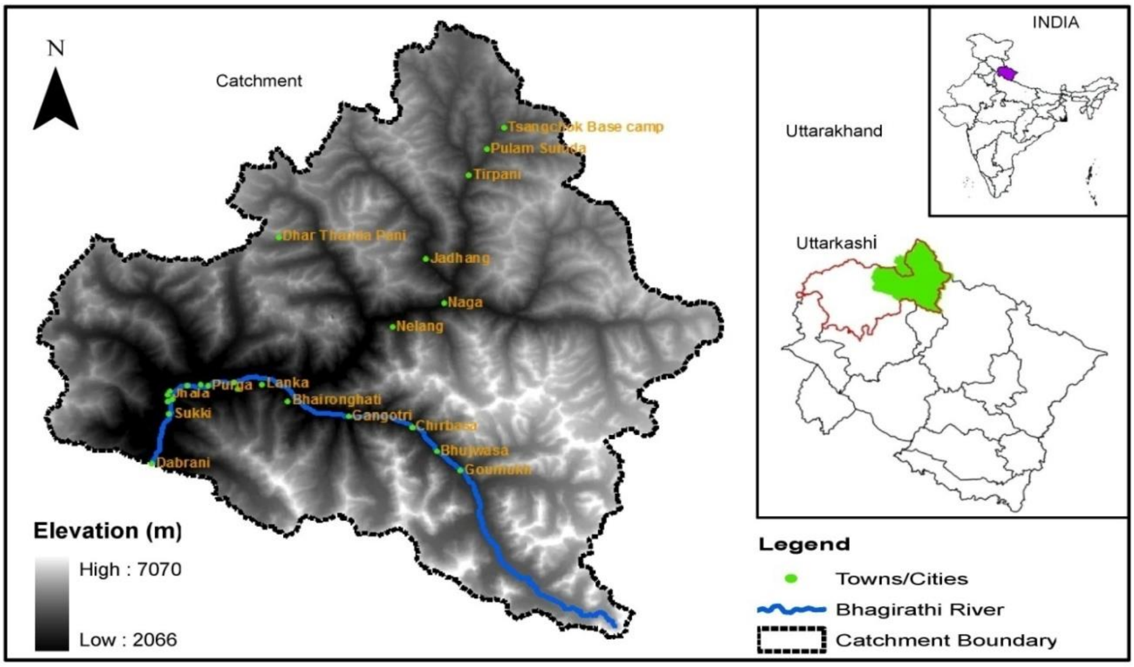
- New water loggers provided by BGS, UK will be installed shortly.
- The water samples were collected from piezometers.

Future plan

- Installation of new loggers
- Downloading data from SEC and water level loggers
- Collection of samples from piezometers
- The hydro-meteorological data will be collected from state departments.
- Data analysis work will be carried out with respect to various parameters like rainfall, land use etc. to observe the seasonal and spatial variation.

3. PROJECT REFERENCE CODE: NIH/GWD/NMSHE/16-20

Title of the study	:	**Study of River - Aquifer Interactions and Groundwater Potential at Selected Sites in the Upper Ganga Basin up to Dabrani**
Type of study	:	Sponsored by DST under NMSHE SP-8
Date of start (DOS)	:	January 2016
Scheduled date of completion	:	December 2020
Location	:	Bhagirathi Basin up to Dabrani (Uttarkashi)



Study objectives:

1. Understanding of river-aquifer interaction and dynamic processes in Himalayan environment,
2. Groundwater potential assessment and availability prospects resulting from snow and glacier melt recharge.

Approved Action Plan:

- Collection/procurement of available long-term hydro-meteorological and hydro-geological data for the study area.
- Preparation of various thematic layers (sub-basins, geology, soils, wells, snow cover, drainage, monitoring network, water use, etc.).
- Selection of suitable sites for piezometer development.
- Development of piezometers for monitoring of groundwater.
- Developments of lithologs and aquifer characterization.
- Collection of water samples and monitoring of groundwater levels.
- Analysis on the stream-aquifer interactions and dynamic processes.
- Estimation of groundwater recharge and water potential.

Time-line and Justification for time over runs:

Piezometer development work in progress by the Uttarakhand Jal Sansthan (UJS), Uttarkashi.

Objectives vis-à-vis Achievements:

Part of Objectives	Achievements
Literature review	Completed.

Database preparation	DEM, drainage, sub-basins, 3D map, slope map, sampling location, geology, landuse, soil.
Selection of sites for piezometer development	- Sites were selected. - Map for selected sites also prepared.
Data collection	Geological map, litho logs of five locations, water quality, isotopic data from water sampling, rainfall and meteorological data from IMD and CWC.
Piezometer development	Being done.

Recommendations/ Suggestions in previous meetings of Working Group/ TAC/ GB: Nil

Analysis of Results:

The study is envisaged on the stream/river and groundwater flow interactions and dynamics including potential assessment emerging from snow and glacier melt recharge to answer the question of groundwater development prospects in the hilly areas as well as base flow regimes of the mountainous streams. In order to carry out the study, the existing basin information, geological and geo-hydrological investigations and development of piezometers for groundwater data acquisition are necessary. The study area, lying in the Uttarkashi district of Uttarakhand state, comprises an area of 3,487.06 sq.km. The Bhagirathi is the main river of the study area. The elevation of the basin varies from 2,066 to 7,070 m above mean sea level. Under the study, various thematic maps viz., digital elevation model, demarcation of basin boundary up to Dabrani, study area map, elevation zone map, 3D map, geological map, drainage map and stream ordering, sub-basin map, slope map, aspect map, digitization of ground surface contours at 10 m interval (SOI at 1:50,000), sampling location map, piezometer sites map, soil map, landuse, etc. have been prepared. Geological traversing from Dabrani to Gangotri was also done. Borelog data of five locations were collected and analyzed. The soil map of the area has also been prepared.

Water sampling from Bhagirathi river, precipitation and groundwater is being continuously done at 10 daily frequency at ten locations for the isotopic and water chemistry analysis for studying the stream-aquifer interactions. These water samples are being collected from springs, river, stream, hand-pumps and rainwater on event-basis for the isotopic and water chemistry analysis. Preliminary interpretations indicate that isotopic values for most of the river and groundwater samples rest close to the Local Meteoric Water Line which indicate the mixing of surface water and groundwater. The piezometer development work is being done at three locations in the study area.

Adopters of the Results of the Study and their Feedback: Study yet to be completed.

List of Deliverables:

- Reports; Research papers; Training Workshops.

Major Item of Equipment Procured: GPS, pH Meter, EC Meter and Water Level Indicators.

Lab Facility used during the Study:

- Centre of Excellence for Advanced Groundwater Research
- Nuclear Hydrology Laboratory
- Water Quality Laboratory
- Soil Water Laboratory

Data Procured/ Generated during the Study:

- Geological map; Water quality data; Isotopic data; Surface contours; Land use; Soils; Bore logs.

Study Benefits /Impact:

- Process understanding of groundwater recharge due to glacier and snow melt recharge.
- Understanding dynamics and behavior of soil-snow interface in the snowmelt Himalayan region.

Specific linkages with Institutions: DST, UJS

Future Plan:

- Generation of borelogs
- Aquifer characterization
- Monitoring of groundwater levels
- Collection and testing of soil samples from various locations of the basin
- Collection and testing of water samples from surface and groundwater for quality and isotopic analysis (groundwater, spring, rainfall and river samples)

4. PROJECT REFERENCE CODE: NIH/GWD/NIH/16-19

Title of the Project: Grey Water to Blue Water – Natural Treatment Techniques for Transforming Wastewater into Sustainable Useable Water.

Status: Submitted to drop this study.

5. PROJECT REFERENCE CODE: NIH/GWD/DST/18-20

Title of the Project: Future Secular Changes and Remediation of Groundwater Arsenic in the Ganga River Basin - FAR GANGA

Type of Study: Sponsored by Indo-UK Project: DST-NERC-EPSRC Newton Bhabha Fund

Nature of study: Applied Research
Duration: 3 (three) years: 01/2018-12/2020
India Project Partners: NIH (India Lead); IIT Kharagpur; IIT Roorkee; and Mahavir Cancer Sansthan, Patna.
UK Project Partner: University of Manchester (UK Lead), British Geological Survey, Salford University; and Univ. of Birmingham.

Aims:

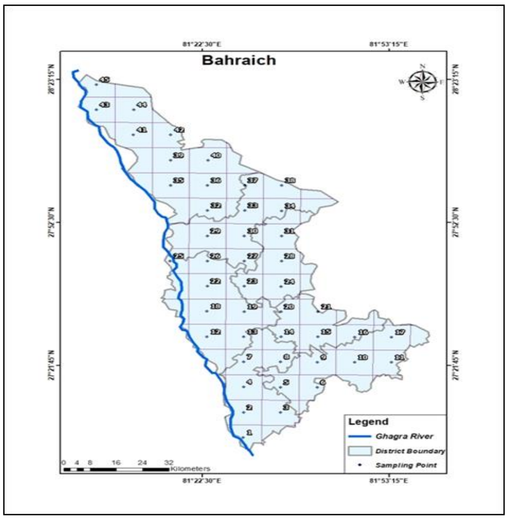
- Investigate the vulnerability of representative shallow sedimentary aquifer systems in the Ganges river basin to secular increases in arsenic
- Predict future secular changes in groundwater arsenic
- Communicate with key stakeholders to inform them of future hazards and risks and how groundwater management practices and strategic selection of water remediation technologies and approaches might accordingly be modified.

Objectives:

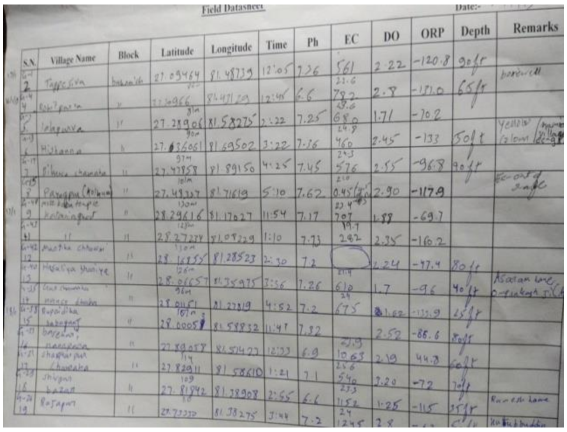
- Produce a national risk assessment of shallow groundwater arsenic from carefully selected tectonic, geological, geo-morphological and climatic variables;
- Produce recommendations for the remediation/ mitigation of human exposure and health risks arising from current and future arsenic prone groundwaters, with a particular focus on managed aquifer recharge (MAR), based on the data and models generated in this project, together with strong and effective participatory approaches with key stakeholders/end-users and by networking with other relevant research and water resource management institutions and projects.

Progress

After the last Working Group meeting in October 2018, one field visit for sampling campaigns (soil and water) in the Bahraich and Ballia along Ghaghara river for a period of more than 15 days during January 2019 was carried out. Analysis of soil and water samples to detect soil and water chemistry are in progress. In between October and December 2018, Indian partners had finalized the field monitoring protocol and also the responsibility of each partner. In some places, the UK partners are providing field support and equipment support.
On 10th December 2018, Expert Panel of the DST had reviewed the progress of the project. All Indian partners are working in close liason. NIH has to install 4 to 6 piezometers of variable depths in Bahraich/Ballia, for which cost estimate was prepared and reviewed by a field expert. The development of 4 piezometers is in tendering stage. Intensive samplings and analysis of samples would be carried out during the second year (2019) of the project. Progress during the 1st year of the project was slower than the planned time line.



Sampling locations and a snapshot of sampling campaign in Bahraich district along Gaghara river


Field Datasheet
Date:-

S.N.	Village Name	Block	Latitude	Longitude	Time	Ph	EC	DO	ORP	Depth	Remarks

Datasheet of sampling campaign in Ballia and a snapshot of sample collection from an observatory tube well

The next review meeting of the consortium is scheduled during 15 – 18 May, 2019 in Manchester, UK.

6. PROJECT REFERENCE CODE: NIH/GWD/DST/18-20

Title of the study : Impact of Rainwater Harvesting on Groundwater Quality in India with Specific Reference to Fluoride and Micropollutants

Type of study (sponsored/consultancy/referred/internal): Sponsored Indo-UK Project: DST-NERC-EPSRC Newton Bhabha Fund**:** Rs. 255.884 lakh (total)

NIH Budget**:** Rs. 105.688 lakh (incl. overhead)
IIT Ropar Budget: Rs. 74.92 lakh (incl. overhead)
IIT Jodhpur Budget: Rs. 75.276 lakh (incl. overhead)

Nature of study: Study components include technology development, technology dissemination, technology adaptation, capacity building

Location Map

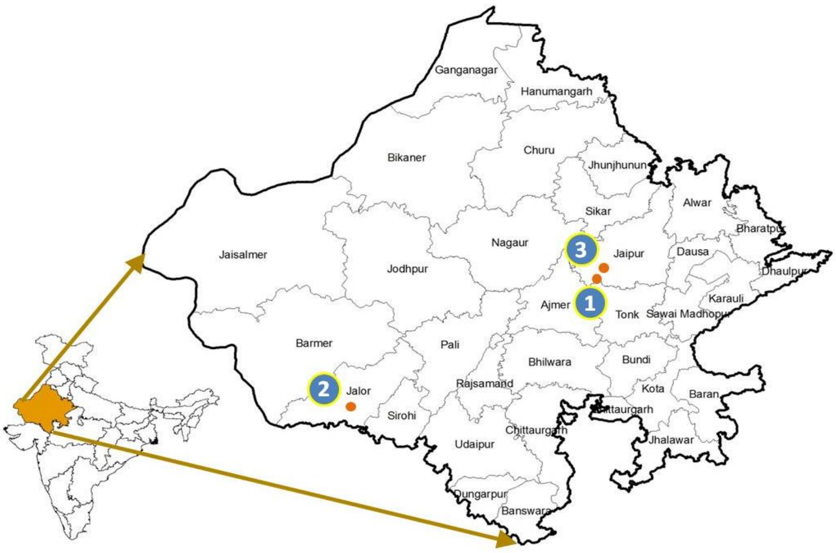


Fig. Locations of study sites in Rajasthan

Project Aim & Objectives

To assess the impact of rainwater used for MAR on groundwater quality and specifically understand how DOM present in rainwater affects fluoride and other pollutant levels, thereby improving MAR structure design and management practices. Specific objectives:

1. Evaluate water level and quality at three selected MAR sites in Rajasthan;
2. Assess the proportion of recharged groundwater attributable to MAR systems at selected sites;
3. Investigate the consequences of recharging aquifers with rainwater on the fate and transport of pollutants into aquifers, and understand the role of rainwater DOM levels in remediating fluoride and other groundwater contaminants;
4. Develop analytical protocols to facilitate the detection of micropollutants in water bodies;
5. Understand the interactions of local users with the MAR structure and also their role in water management.

Work Packages

WP1: Field Surveys & Investigations
WP2: Laboratory Experiments & Analysis
WP3: Simulation of Pollutant Transport
WP4: Research Impact and Knowledge Dissemination

Objectives vis-à-vis Achievements:

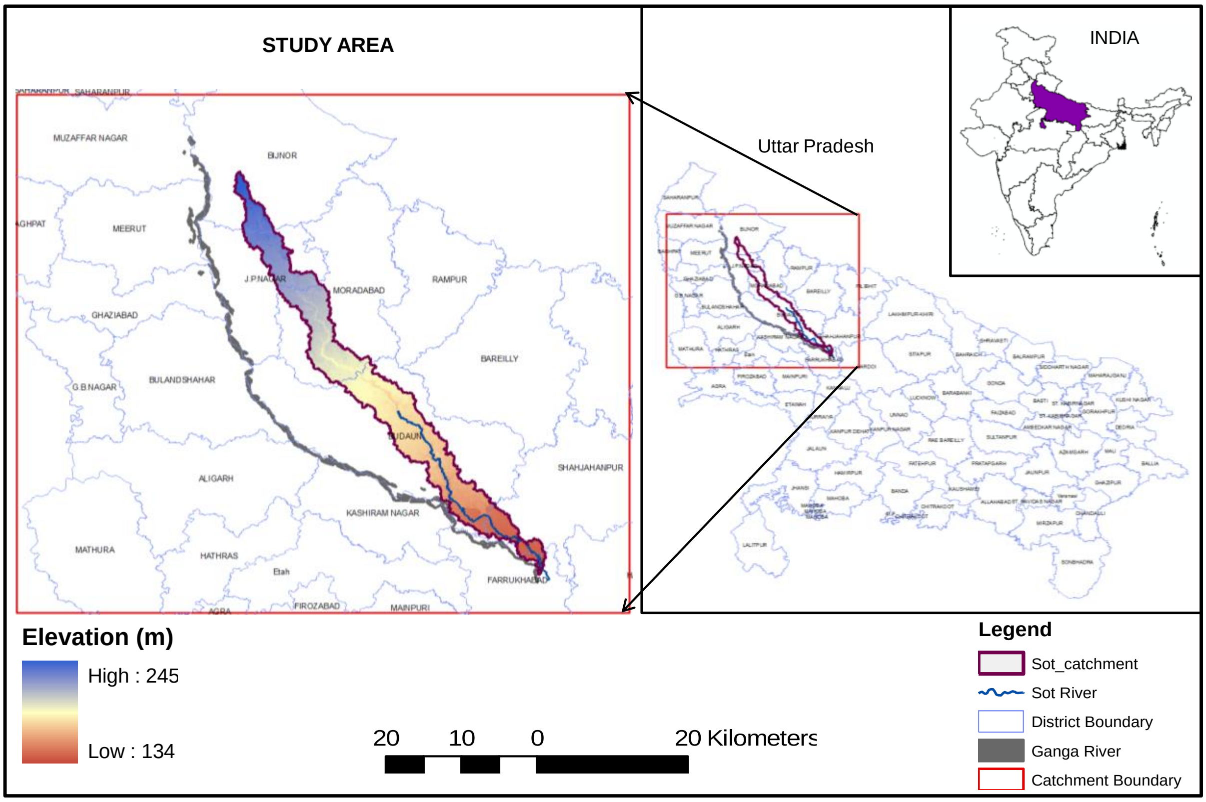
Objectives	Achievements/ Activities
Data collection	Historical groundwater level data from State and Central Ground Water Depts., crop cultivation, relevant reports and maps, meteorological data, data collection during field visits.
Field experiments and laboratory investigations	– Three field visits October 2018, December 2018, March 2019 – DTWL measurements in Laporiya watershed and Bhadrajun – Collection of soil (disturbed/undisturbed) and water samples – Field experiments for saturated hydraulic conductivity and infiltration – Socio-economic surveys – Laboratory experiments for grain size analysis, ICW and soil moisture retention curves – Chemical analysis of water samples – Drilling of boreholes to be initiated with support from State Dept
Database preparation	DEM, land use, soil texture, drainage, groundwater levels, water quality
Data analysis and Website development	Analysis of water level and water quality data, satellite data, land use; analysis of soil samples and data for infiltration rates and saturated hydraulic conductivity; chemical analysis of water samples; Project website developed
Organization of Indo-UK Consortium Meetings	Webex Meetings held on Dec. 12, 2018; Feb. 04, 2019; Apr. 02, 2019

Deliverables & Beneficiaries: The project primarily addresses the Newton-Bhabha priority area "public health and well-being". Beneficiaries will include fluoride affected communities in Rajasthan. Deliverables include research papers, reports, software, manuals, brochures, flyers, users' interaction workshops.

7. PROJECT REFERENCE CODE: NIH/GWD/PDS/18-22

Title of the study : **Ganges Aquifer Management in the Context of Monsoon Runoff Conservation for Sustainable River Ecosystem Services – A Pilot Study**

Type of study : Sponsored by NHP under PDS
Date of start (DOS) : March 2018
Scheduled date of completion: February 2022 (Four Years)
Location : Sot River Catchment (Uttar Pradesh)



Study objectives:

- Hydro-geological characterization of the area
- Analysis of meteorological and hydrological variables *vis-a-vis* cessation of river flows during lean season
- Estimation of surface water and groundwater availability
- Analysis of stream-aquifer interaction
- Aquifer management measures for enhancing river flow during lean season

Statement of the problem:

Declining groundwater levels, diminishing river flows, turning perennial rivers into ephemeral rivers, impact of climate change are posing extreme scarcity of water availability in many tributaries of the Ganga river. Such phenomena are not only affecting the water resources but also the livelihood of farmers and the river ecosystem.

The study area comprises of the catchment of Sot river, a tributary of the Ganga river. The river flows in between the Ganga and the Ramganga river. Though both these rivers have good water potential, the Sot river is drying-up in recent years after monsoon season, and its catchment faces acute water problem and many hydrological problems, including extra-deep groundwater levels, recurrent droughts, soil erosion and desertification in some of the areas. The catchment area falls in districts of

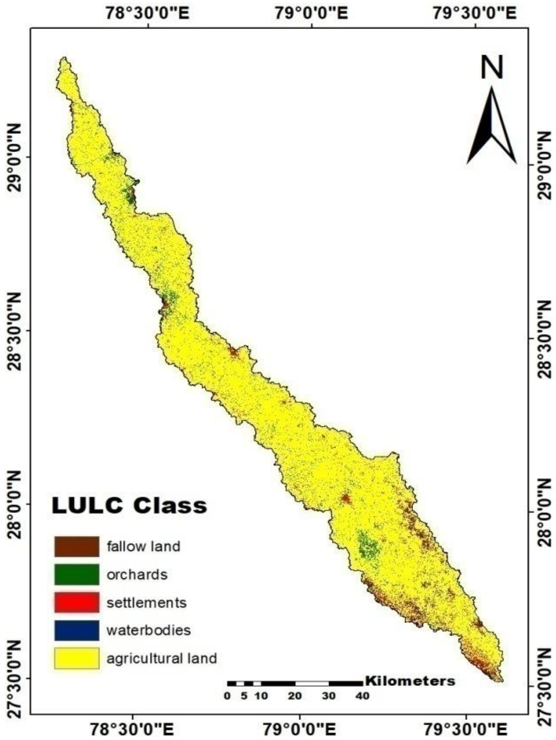
JP Nagar, Moradabad, Budaun, Shahjahanpur and Farrukhabad. The region suffers from extended droughts, depleted water resources, declining groundwater levels, and uncontrolled developmental activities. These factors coupled with the threat of the impending climate change may lead to an aggravation of the crop losses and desertification process in the area. The Sot river, earlier used to be perennial, has now become seasonal river. Under this background, it was felt necessary to investigate the river-aquifer interactions and dynamics to identify causes of drying of river and suggest measures for rejuvenation.

Methodology:

- Aquifers will be delineated using litholog/ borelog data by developing fence diagram, cross-sections, profiles and 3D model in the Rockworks software.
- Time series analysis will be carried out by synchronizing various temporal data (rainfall and groundwater) to study the variation in river flows and the cessation of river flows during the lean seasons of various years.
- Parametric and non-parametric trend analysis using Mann-Kendall and Sen-Slope Estimator, and change detection using Pettitt technique will be carried out on the hydro-meteorological variables to find the declining trends in river flows, groundwater levels and rainfall during both monsoon and non-monsoon seasons in various years.
- Surface water availability shall be estimated from river flow data using flow-duration curve and groundwater availability using GEC-2015 methodology.
- Vulnerability analysis shall be carried out using SAHP/DRASTIC approach.
- Catchment water balance shall be carried out using mass balance approach.
- Integrated surface water and groundwater modelling shall be used for river-aquifer interactions and future scenarios for river flows during lean seasons.
- Isotopic analysis shall also be carried out to verify the reaches of recharge/discharge zones to/from the river.
- A management plan will be developed for the enhancement of water resources both surface and underground.

Analysis of Results:

The study is envisaged on the river and groundwater flow interactions and dynamics to answer the questions on drying of Sot river. To carry out the study, existing catchment information, literature survey, meteorological, hydrological and geo-hydrological investigations, and groundwater data acquisition are essential. Review of literature related to the study has been completed. The study area lies in the Uttar Pradesh state of India and covers an area of 3,027 sq.km. The elevation of the catchment varies from 138 to 245 m above mean sea level. Various thematic maps have been prepared which include digital elevation model, study area map, 3D map, drainage map, soil map, stream ordering, land use, grid maps, etc. The spatial variation of groundwater levels in the Sot catchment is analyzed for the period 1998 to 2017. IMD gridded rainfall and temperature data have been analyzed from 1970 to 2016 and 2015, respectively for temporal and spatial variation on weekly, monthly and annual basis. Non-parametric trend analysis has also been carried-out. The landuse map of the catchment for year 2008 is shown below, while for the year 1998 is under preparation:



Soil samples have been collected from 48 locations in the study area for generating soil information. At all these 48 locations, hydraulic conductivity and infiltration tests have also been conducted. Processing of conductivity and infiltration data is in process. Soil samples are being analyzed for determination of soil texture in the Soil and Water Laboratory. These data and information shall be used in the surface water and groundwater modelling.

Adopters of the Results of the Study and their Feedback: CGWB; Agric. Deptt., GWD and IWRD, Govt. of U.P.

List of Deliverables: Reports; Research papers; Training Workshops.

Lab Facility used during the Study:

- Centre of Excellence for Advanced Groundwater Research
- Soil and Water Laboratory

Data Procured/ Generated during the Study:

- Toposheets, DEM, Meteorological data, Soil information, Groundwater Levels, Landuse, River flows

Study Benefits /Impact:

- Increased surface water and ground water availability - Regional water security
- Farmers' access to irrigation
- Social and cultural activities
- Improvement in water quality by continuous flushing and dilution of domestic and industrial wastewaters
- Economic benefits through livelihood upliftment
- Climate resilience

Equipments to be Procured: Aquameter, EC and pH meter

Future Plan:

- Characterization of sub-surface formations
- Determination of soil texture
- Analysis on variation of river flows

- Collection and testing of water samples from surface water and groundwater for quality and isotopic analysis (groundwater, rainfall and river samples)
- Mapping of changes in land use and water bodies
- Estimation of evapotranspiration
- Analysis on changes in cropping pattern and demographic changes
- Analysis of changes in water demands and irrigation supplies, cropping intensity, etc.
- Catchment water balance

8. PROJECT REFERENCE CODE: NIH/GWD/PDS/18-20

Title of the study : **Assessment of Impacts of Groundwater Salinity on Regional Groundwater Resources, Current and Future Situation in Mewat, Haryana – Possible Remedy and Resilience Building Measures**

Type of study : Applied Research
Date of start (DOS) : January 2018 (NHP-PDS)
Scheduled date of completion : December 2020
Location : Mewat district, Haryana

Study objectives:

1. Assessment of lowering of water table (depletion in groundwater level) in the salinity impacted area using the historical data
2. Detailed qualitative analysis of the area and the aquifer depth impacted by higher salinity levels, and preparation of maps
3. To monitor influx of saline groundwater into fresh water zone
4. To assess the impact of groundwater salinity on socio-economic aspects
5. To develop and demonstrate management and resilience building measures

Statement of the problem:

Groundwater salinity is a widespread problem in many productive agricultural areas in India including many districts in Haryana. Aquifer salinization gradually affects the agro-economy, livelihoods and drinking water supply in local and regional scale due to lowering of groundwater levels. Salinity is the main factor limiting the continued use of groundwater in surface water scarce area, and future reliance on groundwater is further diminished as groundwater levels decline, creating increases in salinity and in exploitation costs. A systematic groundwater development and management fulfilling the technical needs of supply-side and demand-side components can arrest the aggravation of salinity and provide sustainable solution to problem.

The proposal deals with to undertake a comprehensive study on hydrological and hydrogeological features together with chemistry and isotopic characteristics of groundwater for evaluating the causes of aquifer salinity including its aggravation and effect on agro-economy, drinking water supply and livelihoods considering the problem of Mewat district in Harayana as the pilot study areas. A few demonstrative schemes as resilience building measures towards arresting the aggravation of salinity and increase of managed aquifer recharge together with their impact assessment on overall groundwater resources are also proposed to undertake. Development of a model to predict changes in groundwater salinity as a result of aquifer recharge and extraction is another focus of the study.

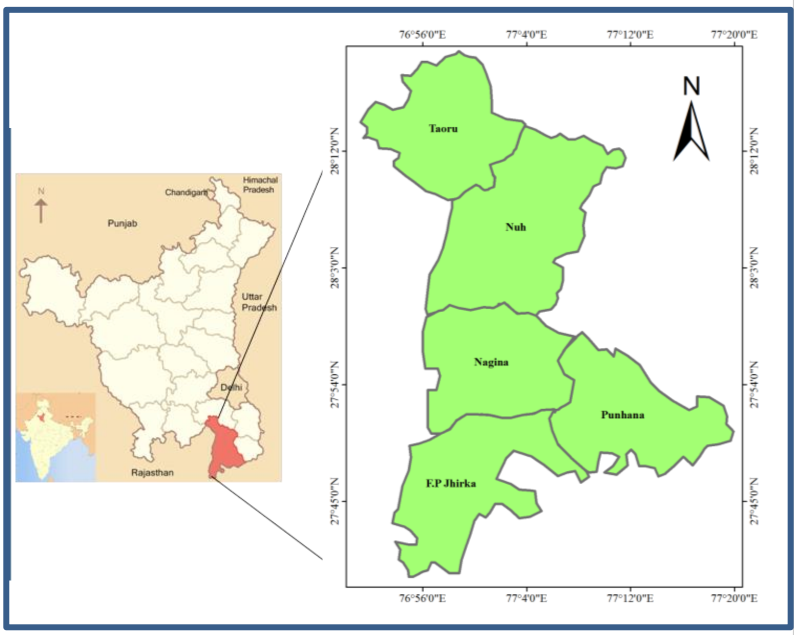


Fig. Map of Mewat district

Whether Study is a New Study/Extension of Previous Studies: No

Methodology:

This work will be accomplished in five phases as identified below:

- In Phase 1, socio-economic based survey will be carried out to find out the impact of salinity on the socio-economic condition of the people on the basis of list of indicators. The findings of the study will help in initiating the development activities as coping strategies for the survival of humankind in the presence of salinity in the district of Mewat. The study proposed to employ both qualitative and quantitative method. Under the quantitative method, a well structured coded interview schedule will be used. Focus Group Discussion (FGD), as a qualitative method, will be administered to collect information on the above socio economic characteristics of the farmers.
- Phase 2 of the study will begin with developing of a hydrogeological framework of the aquifer system in Mewat district based on all existing lithologic, stratigraphic and hydrologic information that may be available from various agencies. The saline areas in the district will be mapped.
- Phase 3 will include a hydro-chemical characterization (on the basis of anions, cations physico-chemical characteristics etc.) and quantification of salinity.
- Phase 4 will target the areas surrounding the drinking water wells that showed presence of salinity in Phase 2 using existing and new tube wells. Further, the water extracted from tube wells within and down gradient from the industrial areas will be examined where untreated wastewater may have been disposed on the surface (e.g., in infiltration ponds) or injected into the subsurface. The main purpose of the study in Phase 3 will be to identify cause/source areas using isotopes (release locations).
- Phase 5 will include suggestion and development of resilience building measures. Some proposed measures will be construction of hydraulic barrier, solid barriers (clay); high pressure recharge.

Progress

- Field work was conducted for pre-monsoon water sampling in April, monsoon in August and post monsoon in October, 2018.
- Water level data for 2004-2017 has been collected from State Agriculture Department.

- Rainfall data has been collected from State Revenue Department.
- Experimental model has been fabricated and experiment work is in progress.
- Work of socio-economic survey has been awarded to Sehgal Foundation, Gurgaon.
- Procurement of field instruments (EC probe and water level recorders) is in progress.

Groundwater level variation data reveals that rate of water level decline (2004-2017) in Tauru and Firozepur Jhirka is higher due to the higher extraction of potable groundwater from the wells in the Aravali foothills as compared to other 3 blocks. Rate of extraction of groundwater is low in central part of district comprising of Nuh and Nagina blocks due to high salinity. Groundwater samples were collected for EC measurement from Nagina and Firozepur Jhirka blocks in the month of April for pre-monsoon (24 nos.); from Nagina, Firozepur Jhirka and Tauru blocks in the month of August for monsoon (29 nos.) and October for post-monsoon seasons (29 nos.) in the year 2018. EC variations and their extent was mapped using ARC GIS software. Average EC (µS/cm) during different seasons is recorded as pre-monsoon 9173; monsoon 7831; post monsoon 7561. A decrease of 1612 µS/cm from pre to post-monsoon was found thereby decreasing the area under high to very high EC (>12000 µS/cm) by 20.5 km^2 in the monsoon season.

The experiment on development of freshwater pocket in saline zone is under process so that suitable management measures for the salinity affected areas may be developed. For this, the experimental model has been fabricated and is shown in figure below.

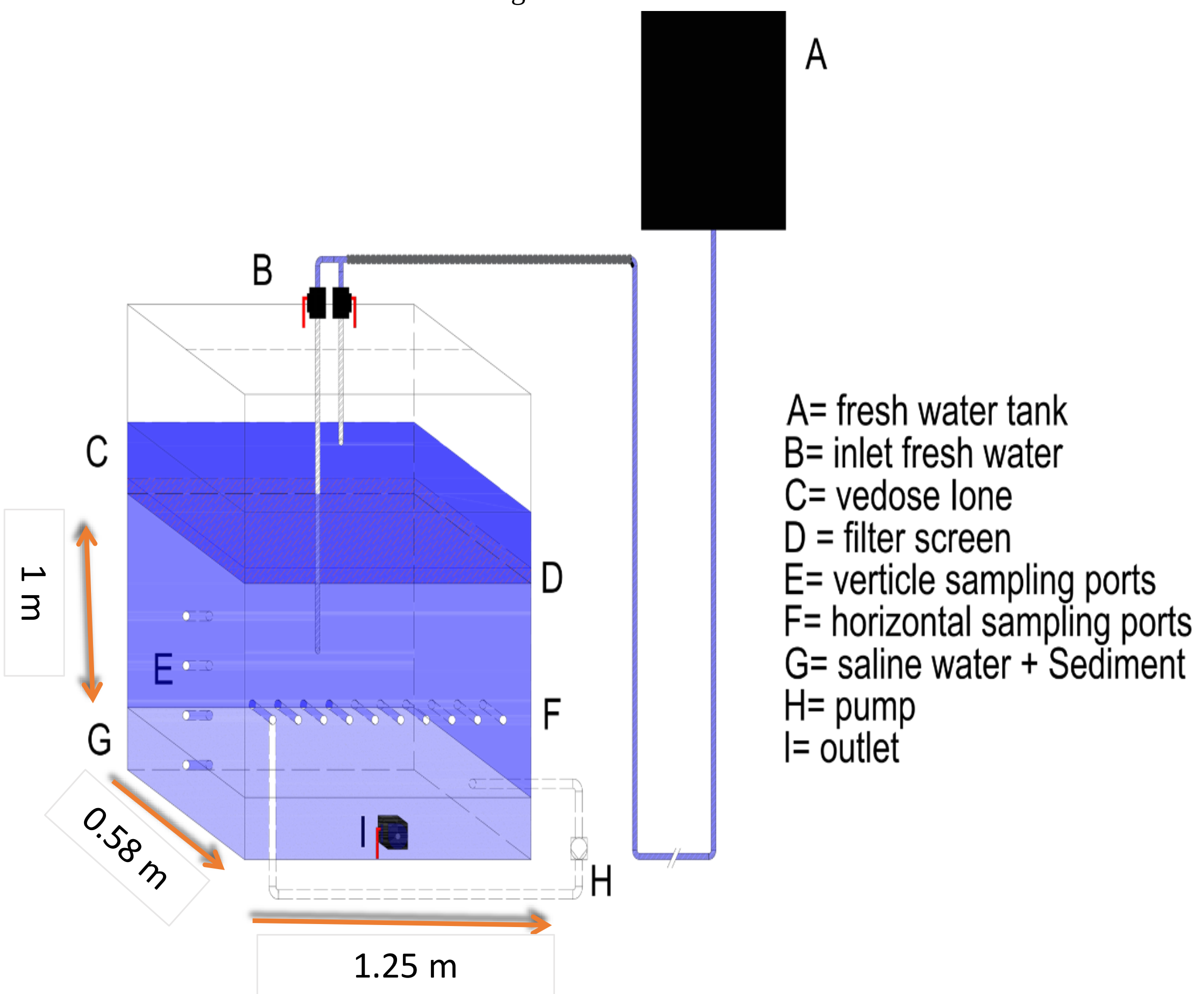


Fig. Experimental model

Description of work planned:

- Experiment on salinity
- Continuation of sample collection for pre monsoon, monsoon and post monsoon
- Procurement of field instruments and their installation

Action plan:

Year	Jan 2018 to Dec 2020	Remark
2018 to 2020	Data collection on available groundwater studies including water table, water quality and other hydro-geological aspects in Mewat district Collection of water and soil samples to assess the salinity conditions Dissemination of outputs in a workshop/review meeting under the project	Report preparation as per Activity Schedule

Study Benefits /Impact:

- Problem of salinity to be identified
- Suggesting the suitable remedial measures

Specific linkages with Institutions: Irrigation department, Haryana**,** IIT-Roorkee, Sehgal Foundation-Gurgaon

Activity Schedule for the Baseline Data Collection and Analysis in Mewat, Haryana **(Quarter Wise from Jan. 2018 to Dec. 2020)**

Item/Period quarterwise	1	2	3	4	5	6	7	8	9	10	11	12
Data/literature collection												
Field Surveys												
Sample collection												
Analysis												
Data interpretation												
Suggestions/remedial measures												
Report writing/publications												

Data requirement & Expected source: Hydro-meteorological data will be collected from the state departments.

IPR potential and issues **:** Filed a patent vide no. UCS&T/PIC/PATENT-33/2018-19.

Major items of equipment needed: EC-probe for soil salinity and; water level and conductivity loggers, rain gauges and drilling of piezometers.

9. PROJECT REFERENCE CODE: NIH/GWD/PDS/18-20

Title of the study	:	Hydro-Geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin
Type of study	:	Sponsored (NHP)
Date of Start	:	January 2018
Scheduled Date of Completion	:	December 2020 (3 years)
Budget	:	Rs.70 lakh
Location	:	Bhojpur District, Bihar

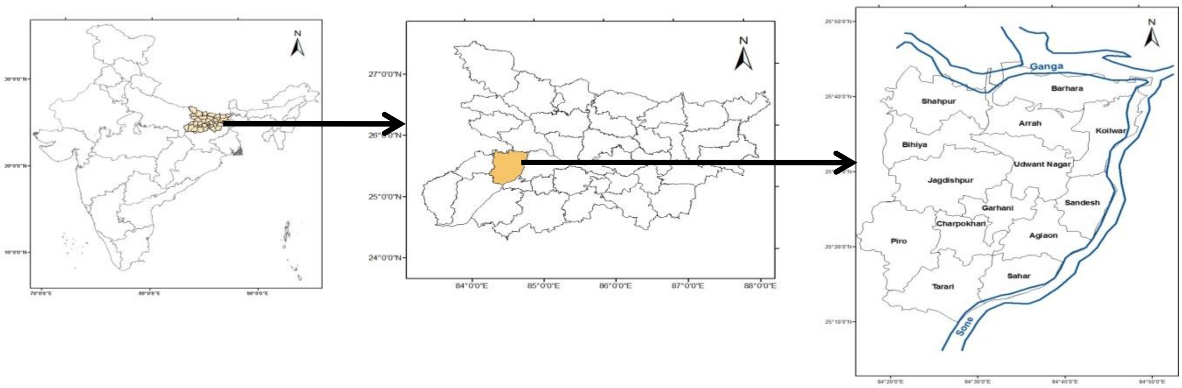


Figure: Study Area

Objectives

- Determination of the spatio temporal variation of arsenic along with other water quality parameters in groundwater
- Delineation of arsenic safe zone for drinking water supply
- Evaluation of the controls of regional and local hydrology on arsenic contamination through monitoring of contaminated aquifer
- Evaluation of the mechanism of transport of arsenic in geo-environmental through a column experiment

Statement of the problem:

The symptoms of chronic arsenic (As) from prolonged consumptions including skin lesions began to be observed in early 1980 in residents of the lower Gangetic plains of West Bengal and adjoining Bangladesh. Subsequent research over the years reported that elevated As (relative to a 10 µg/L drinking-water standard of World Health Organization) is widely present in the potable groundwater, and as many as 15 million residents in West Bengal and 35 million residents in Bangladesh are at risk. This led to a huge number of hydro-geological studies in the lower Gangetic plain and delta for identification of the source and cause of As-contamination. But there is very little information available for central Ganges basin. The central Ganges basin comprising mainly Uttar Pradesh and Bihar is one of the largest fluvio-deltaic systems and most populous regions of the India. In recent few decades, the increasing demand of groundwater for domestic, irrigation (round the year for food production) and industrial with the growing population rate led the extensive exploitations of fresh and potable groundwater.

In last decades, few investigators reported the elevated arsenic concentration and the process of the contamination in central Gangetic basin, but none seems to have studied the fate, transport and mobilization of the arsenic although initial estimates indicate that the poisoning might be widespread and several million people may be at risk. The study is focused on the hydrogeological controls on arsenic mobilization, fate and transport in order to develop an understanding of arsenic release mechanism and demarcation of arsenic safe aquifer for Bhojpur district, Bihar (Central Ganges

Basin). Inferences about the processes controlling the composition of groundwater will be evaluated from field measurements, statistical analyses and geochemical modelling. Column experiment will be performed to define the fate and contaminant transport and conclusions would be made by combining the above mentioned techniques with geospatial analyses to identify the safe aquifer.

End Users/ Beneficiaries: Minor Water Resources Dept., Govt. of Bihar, Public Health Engineering Department, Govt. of Bihar, Ministry of drinking water and Sanitation, Govt. of India, NGOs, Local Community etc.

Objectives & Achievements

Determination of the spatio-temporal variation of arsenic along with other water quality parameters in groundwater.	Groundwater samples during pre and post monsoon season (year 2018) have been collected. The chemical analyses for samples collected in pre-monsoon has been completed and for post monsoon, analyses are under progress. Spatio- temporal variation would be studied after analyzing the results of post-monsoon data.
Delineation of arsenic safe zone for drinking water supply.	Arsenic safe zone map will be prepared based on pre & post monsoon data.
Evaluation of the controls of regional and local hydrology on arsenic contamination through monitoring of contaminated aquifer	The site for piezometer construction has been identified and the process for drilling has been initiated.
Evaluation of the mechanism of transport of arsenic in geo-environmental through a column experiment.	Yet to start.

Analysis and Results: Sampling in the pre and post monsoon, 2018 has been completed based on 4 x 4 km grid size. A total of 153 samples were collected from all fourteen blocks of the Bhojpur district. The chemical analyses of pre-monsoon have been completed; however, interpretation of post-monsoon season data is under progress. The water quality results revealed that the blocks situated along Ganga river are affected with As (ND-365 µg/L) while blocks along Son river are not affected by the As. The Hydro-geological and geo-chemical study will be done to understand the behavior of aquifers in both the basins. Nest of piezometers will be constructed in both the basins for continuous monitoring and the undisturbed soil samples will be collected for XRD and XRF analyses. Further, lab-scale column experiment will be performed to understand the fate and mobilization of arsenic enriched groundwater.

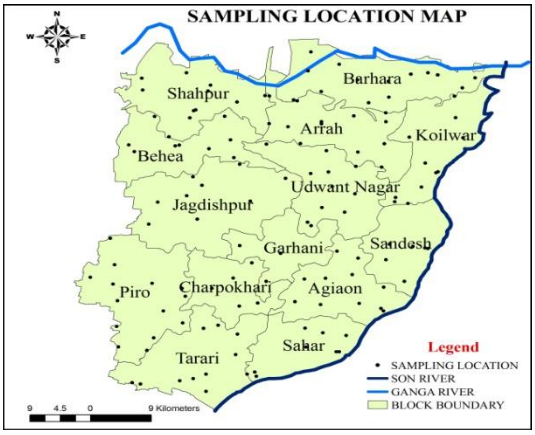


Fig. Sampling location map of study area

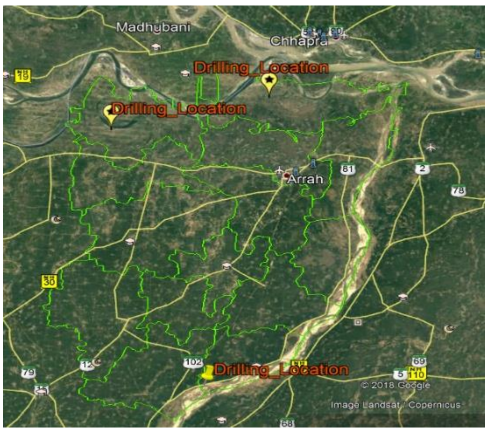


Fig. Probable drilling locations

10. **PROJECT REFERENCE CODE**: **NIH/GWD/PDS/18-20**

Title of the study: Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin up to Delhi

Type of study: Special Study under Centre of Excellence in Hydrological Modelling (NHP)
Date of start: April 2018
Duration of study: Four Years
Location Map:

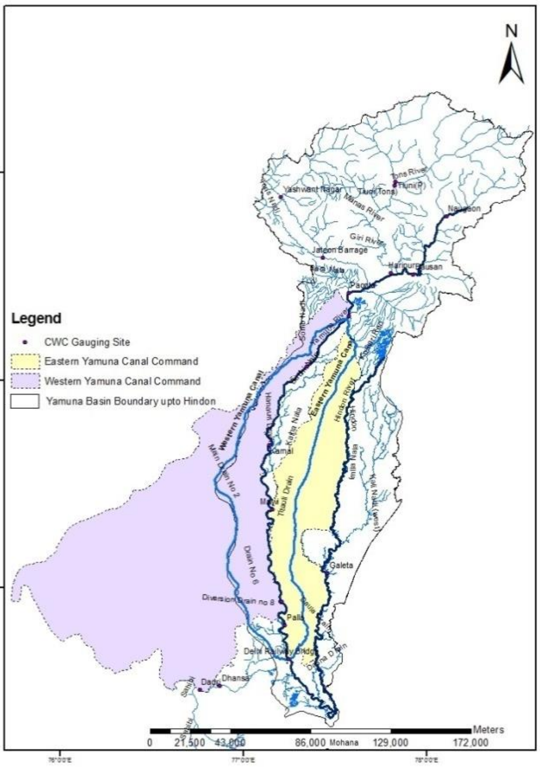


Fig. Study area showing the Upper Yamuna Basin and the command areas of EYC and WYCl

Study objectives:

1. Application and performance evaluation of selected hydrological models for the simulation of the surface water, groundwater, and water quality
2. Quantification of the contribution of snow and glacier melt to surface water resources through snowmelt runoff modelling for the Tons river
3. Assessment of changes in baseflow contribution to river Yamuna.
4. Assessment of present and future water availability under alternate scenarios of climate change
5. Integrated water allocation planning based on present and future scenario of water availability for (i) Eastern Yamuna Canal Command, (ii) Western Yamuna Canal Command
6. Formulation of adaptation measures in the context of climate change
7. Flood frequency analysis and flood plain mapping of river Yamuna
8. Assessment of anthropogenic activities on water quality
9. Numerical modelling of groundwater recharge dynamics and impact of climate variability on renewable groundwater resources
10. Roll out of technical know-how through training workshops for partner organizations

Objectives vis-à-vis Achievements:

Objectives	Achievements/ Activities
Data collection	Historical groundwater level data from State and Central Ground Water Depts., hydro-meteorological data pertaining to river Yamuna, crop cultivation, meteorological data, relevant reports and maps, data collection during field visits, project partners
Field experiments and Laboratory investigations	– Field visits in December 2018 and March 2019 for collection of water samples along Yamuna river – Chemical analysis of water samples in laboratory – Collection of soil samples and field, laboratory experiments
Database preparation	Geo-referencing and digitization of drainage network (including Himalayan terrain); Digitization of canal network in WYC Command and EYC Command; Watershed delineation of UYB upto confluence of Hindon with Yamuna; watershed delineation of Hindon River Basin; Geo-referencing and digitization of soil maps (1:50,000) for area in UP, Haryana, Delhi, HP, Uttarakhand; LULC classification; Database preparation for SWAT, HEC-HMS, MODFLOW.
Hydrological Modeling	Preliminary runs of SWAT / HEC-HMS for sub-basins of Upper Yamuna basin

Deliverables:

1) Application of various models pertaining to surface water hydrology, groundwater hydrology, basin planning, optimal water utilization and their inter-comparison in respect of UYB;
2) Evaluation of the impact of climate change, land use change and population growth on the water resources in UYB;
3) Assessment of changes in baseflow contribution to river Yamuna and strategies to enhance the contribution;
4) Evaluation of impact of climate variability on renewable groundwater resources;
5) Training Workshops for State Department officials of UP and Haryana.

11. PROJECT REFERENCE CODE: NIH/GWD/NIH/19-21

Title of the Project : Assimilation and Application of Satellite Data Products for Water Resources Assessment of In-land River Basins of India

Project team

a. Project Investigator — Ms. Suman Gurjar
b. Co- Project Investigator — Dr. Vishal Singh
c. Investigator(s) — Dr. Surjeet Singh, Dr N. C. Ghosh, Mr. C. P. Kumar

Type of study : Internal
Duration : April 2019 - March 2021

Objectives:

- Assess the applicability of using multi satellite data approach for water resource assessment
- To analyze the accuracy of the satellite data product by calibrating it with the observed data and use the satellite data at places where there is scarcity of observed data
- Explore the use of satellite data on scales smaller for water resources management

Brief about study:

It is well-known that the number and diversity of water-related challenges are large and are expected to increase in the future with the ever increasing human population and rapid depletion of natural resources due to over exploitation as well climate change. Current and future water-related challenges are location and time specific, and can vary from impact of glacier dynamics, economic and population growth, floods or extended and more prolonged droughts, amongst others.

Hydrological modelling is the very important process for the evaluation analysis and assessment of water resources and optimizing the management for optimal results. Hydrologic model is quite important as it is a simplification of a real-world system (e.g., surface water, soil water, wetland, groundwater, estuary) that aids in understanding, predicting, and managing water resources. Both the flow and quality of water with quantity can be studied using the model. There are various models used for hydrological modelling, each model requires very large scale data to perform the calculations, run the model, generate the different scenarios based upon inputs and the model that is eventually selected depends on the problem to be addressed and/or the question to be answered.

Presently there is a very limited scale observed data we usually get, so in a model we use these available data and keeping other data as constant and sometimes try to use such model which doesn’t require much data. But these models don’t draw the true picture of problem and solution needs to address the problems leading to wrong decision making or misinterpretation of results derived from the model, which finally leads to lack of proper water resource planning and management.

So data sets are foremost and critical part for executing any hydrologic model successfully and interpreting actual and proper results for water resources management.
With the dramatic and swift change in technology and computational resources, now-a-days there are different satellite data set available over different resolutions and time durations; the number of parameters have also increased exponentially in satellite data; for some products even few satellites are providing the near to real time data.

The satellite data can help us in hydrological modelling in great manner. So this study is taken up keeping the view and scope of satellite data for hydrological modeling. This study aims to assess the accuracy of satellite based data products for hydrological modelling of water resources and to determine what data is best to use and up to which scale we can use the available dataset.

Study area: In-land basins of India

Methodology:

Estimation of terrestrial water resources is an exceedingly difficult problem as in situ measurements are expensive and are seldom dense enough to capture the spatial heterogeneity of the landscape. Water resources assessment relies on a full understanding of all the water flows and storages in the river basin or catchment under consideration. The process of water resources assessment involves developing a complete understanding, as possible, of these flows and storages and their inter-relationship over time. Only then it is possible to estimate what sustainable surplus flows may be made available for human or other uses as both sources and systems change in the future through climate change, natural evolution or human made interventions.

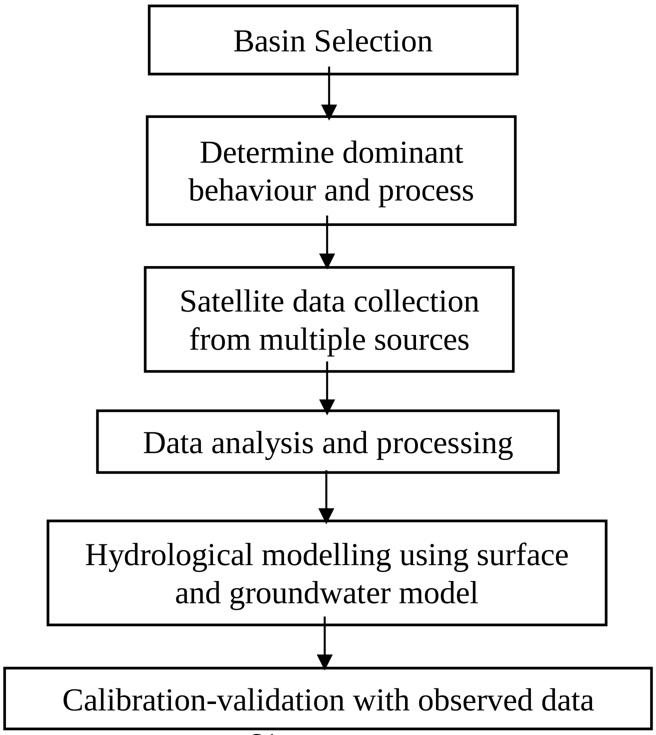
1) The first step in water resource assessment is to identify the basin and determine the processes which are dominant and therefore where subsequent investigations should be targeted.

2) The second step is a comprehensive gathering and collation of recent and historical hydrological available satellite data related to the basin area (for example, surface water resources, groundwater resources). This will include satellite data on precipitation, evaporation, river flow, surface storage, soil moisture and groundwater and, where relevant. Since the data is of different scale and time duration, the further step required is to bring the spatial and temporal data in one resolution scale and common time duration by downscaling/upscaling of data.

3) The third step after having assembled all the data, is to understand the key interactions in the catchment and key features of water balances and use models for assessment of surface water and groundwater utilizing hydrological models such as SWAT-MODFLOW.

4) The results will be calibrated and validated using the observed data at certain locations of the basin, to verify and check the accuracy of the generated results.

Flow chart



Expected Outcomes:

If the methodology is successful and the results give a good accuracy then the satellite products can be used for various hydrological modelling studies, where there is scarcity of data.

1. Hydrological modeling and calibration-validation outcomes
2. Basin wise availability of surface water resources
3. Basin wise availability of groundwater resources
4. Applicability and evaluation outcomes of satellite based assimilated data product in different river basins

Work schedule

a. Probable date of commencement of the project: May 2019
b. Stages of work and milestone:

Project Year	**May 2019-April 2020**				**May 2020-April 2021**			
Project Quarter	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
a. Concept Building and understanding of study basin								
b. Data collection & processing								
c. Modelling Time: Hydrological Model Development								
d. Model calibration and validation								
e. Final Report /Publications								

12. **PROJECT REFERENCE CODE: NIH/GWD/NIH/19-22**

Title of the Project : Integrated Hydrological Modelling to Investigate the Surface-Subsurface Water Interactions

Project team

Project Investigator	Mr. Nitesh Patidar
Co-Project Investigator	Ms. Anjali
Investigator(s)	Mr. C. P. Kumar
	Dr Anupma Sharma
	Mr. Sumant Kumar

Type of study **:** Internal

Duration **:** 3 years (May 2019 - April 2022)

Objectives:

1. To assimilate remote sensing based product in an integrated hydrological model and evaluate its performance
2. To simulate hydrological fluxes, such as runoff, evapotranspiration and groundwater recharge
3. To investigate spatio-temporal variability of surface and subsurface water interactions

Statement of the problem

A thorough understanding of hydrological system is essential for sustainable water resources management. Of particular importance are the exchange of fluxes between the surface and subsurface hydrological systems, especially in the regions where the surface water and groundwater are limited and the exploitation of one impacts the other. The knowledge of surface-subsurface water interaction is required to (i) optimize conjunctive use of groundwater and surface water resources, (ii) assess the influence of groundwater extraction on stream flows, (iii) assess the impact of land cover and climate changes on groundwater; and (iv) assess the risk of groundwater contamination by surface water-borne contaminants and vice-versa. Further, the declining groundwater levels due to over-exploitation has raised several queries about the changes in river water availability due to adverse impacts of aquifer depletion, vulnerability of groundwater contamination, and availability of surface and subsurface water resources in the future. Therefore, to answer these queries and manage water resources in a sustainable manner, comprehensive understanding of surface and subsurface hydrology is essential.

The study area - upper Mahi basin up to Mahi Bajaj Sagar dam - is a semi-arid region with annual rainfall of approximately 887 mm. Due to monsoon dominated rainfall, the basin has repeatedly facing water related issues during non-monsoon seasons. The ever-increasing groundwater and surface water abstractions to cater the agricultural, industrial and domestic needs have led to reduced non-monsoon flow in the river and depleted groundwater levels in the basin. Over-exploitation of groundwater has led to depletion of water table below the safe limits in many parts of the region. These depletions have not only reduced the groundwater availability but could have reduced the baseflow contribution to the streams, and thus have impacted the river flow during non-monsoon seasons. Therefore, it is important to investigate the effect of groundwater depletion on the streamflows. In addition, the quantification of groundwater recharge through the streams has paramount importance in estimating available water resources and forming water management strategies. To the best of our knowledge, no study has been carried out to understand the interactions between surface water and groundwater in the study area. Integrated hydrological modelling of the area will help in understanding the sensitivity of the river flow to the groundwater decline, quantifying the groundwater recharge/discharge from/to the river and finding ameliorative measures for various water related problems.

The study area extends from 22°33'51.32"to 23°33'56.246"N latitude and from 74°23'24.806" to 75°14'51.357"E longitude and has an area of ~4733 km^2. The Mahi River originates at a place near the village of Sardarpur in the Dhar district of Madhya Pradesh and drains into the Gulf of Khambhat in state of Gujarat.

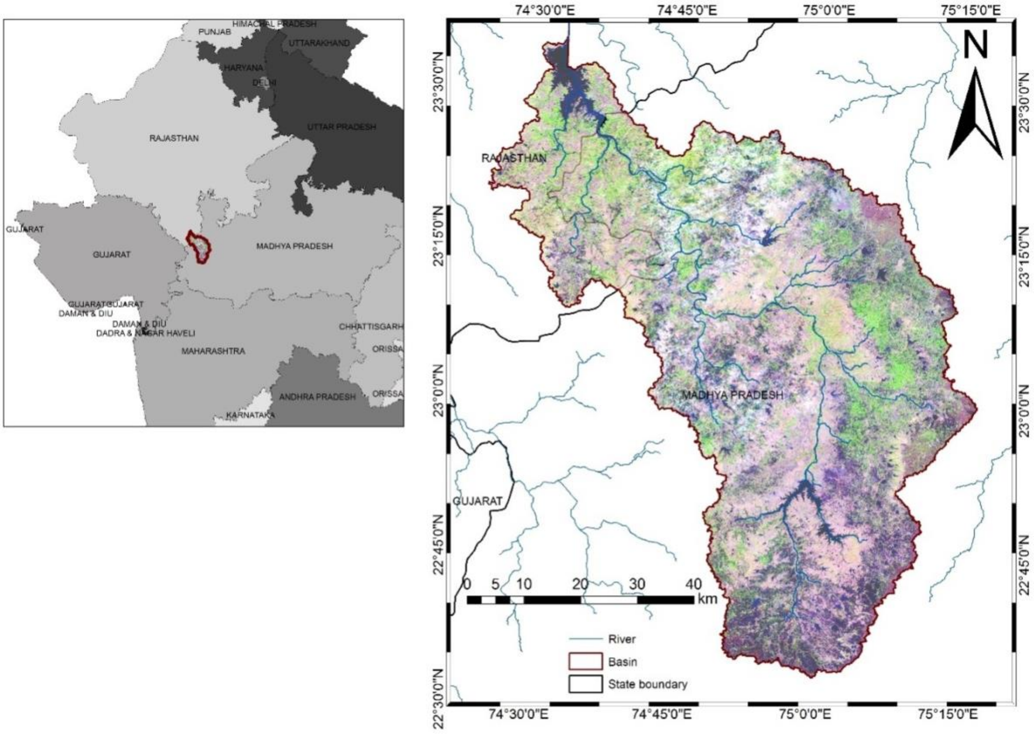


Figure. ***Study area-upper Mahi River Basin up to Mahi Bajaj Sagar dam. The location of the study area is shown in the left panel. The right panel shows the streams and basin boundary overlaid over an image of the Landsat 8 satellite acquired on November 12, 2013.***

Methodology

- Integrated hydrological model, named SWAT-MODFLOW, will be employed in the proposed study. Data required for the model, such as precipitation, temperature, soil type, aquifer geometry, groundwater level etc., will be collected from the concerned departments.
- The model calibration will be performed utilizing in-situ observations of streamflow and groundwater level.
- The remote sensing based hydrological product will be integrated with the hydrological model using a data assimilation technique, such as ensemble Kalman filter (EnKF). One remote sensing product will be selected from various available products, such as soil moisture and Total Water Storage (TWS), based on the data availability and its compatibility with the model.
- A comprehensive evaluation of the integrated model will be performed utilizing various in-situ observations, such as streamflow and groundwater level.
- Simulation runs will be performed to estimate various water balance components, including surface runoff, streamflow, groundwater recharge, evapotranspiration and groundwater level.
- Utilizing the integrated model, interactions between the surface and subsurface water will be studied, especially at the river course. In addition, quantification of the discharge from groundwater to the stream, and vice-versa, will be studied using the model.

Data requirements

- Meteorological data
- Soil, land use and land cover, and topographical data
- Groundwater levels and lithologs
- Remote sensing data, etc.

Beneficiaries of the study

The results and findings of the proposed study will be useful to policy makers for managing surface water and groundwater. The results could also be useful to Water Resources Department, Madhya Pradesh (WRDMP) and local community. The proposed study will involve application of remote sensing data into an integrated hydrological model through data assimilation technique to improve hydrological simulations and thus will help the future studies to obtain reliable results from the hydrological models.

Action plan and timeline (quarter-wise from May 2019 to Apr 2022)

Work element	1	2	3	4	5	6	7	8	9	10	11	12
Literature survey												
Data collection and preliminary analysis												
Model setup and calibration												
Preparation of the data and modification of the SWAT-MODFLOW model source code for data assimilation												
Model evaluation after data assimilation												
Simulation runs for estimating various hydrological components												
Preparation and submission of research paper												
Analysis for understanding surface-subsurface water interactions												
Preparation and submission of reports and research papers												

HYDROLOGICAL INVESTIGATION DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. Sudhir Kumar	Scientist G & Head
2	Dr. S D Khobragade	Scientist F
3	Dr. M S Rao	Scientist E
4	Sri S K Verma	Scientist D
5	Dr. Santosh M. Pingale	Scientist C
6	Sri Hukam Singh	Scientist B
7	Ms. Nidhi Kalyani	Scientist B
8	Sri Rajeev Gupta	PRA
9	Sri U K Singh	SRA
10	Sri V K Agarwal	SRA
11	Sri. Raju Juyal	RA
12	Sri Vishal Gupta	RA

NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्ठा मयोभुवः

Approved Work Programme for the year 2018-2019

SN.	Project Title	Study Team	Duration	Sponsored By / Status
INTERNAL STUDIES:				
SPONSORED PROJECTS:				
1.	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	SuhasKhobragade (PI) Sudhir Kumar Rajesh Singh M. Arora R. J. Thayyen S.K. Verma	5 Years (04/16-03/21)	NMSHE Project ***(Continuing Study)***
2.	Rejuvenation of Springs and Spring-fed Streams in Mid-Himalayan Basin using Spring Sanctuary concept	Sudhir Kumar (PI) S.K. Verma	3 Years (06/16 - 05/19)	Project with GBPIHE ***(Continuing Study)***
3.	Dating very old ground waters of deeper aquifers in Ganga Plains, India	M. Someshwar Rao (PI) Sudhir Kumar C.K.Jain S.K. Verma	3 Years (06/16 - 05/19)	IAEA under CRP ***(Continuing Study)***
4.	Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin	Sudhir Kumar (PI) C.K. Jain M. Someshwar Rao S.K. Verma	3 ½ year (1/18 – 6/21)	PDS under NHP ***(Continuing Study)***
5.	Integrated Study on groundwater dynamics in the coastal aquifers of West Bengal for sustainable groundwater management	M. Someshwar (PI), Sudhir Kumar, S.K. Verma A. R. Senthil Kumar V. S.Jeyakanthan	3 ½year (1/18 – 6/21)	PDS under NHP ***(Continuing Study)***
6.	Development of a comprehensive plan for conservation and sustainable management of Bhimtal and Naukuchiatal lakes, Uttarakhand	SuhasKhobragade (PI) Sudhir Kumar M.K. Sharma	3 Years (1/18 – 12/20)	PDS under NHP ***(Continuing Study)***
7	Climate resilient conservation & data management of spring water sources by strengthening monitoring mechanisms in drought prone areas of Sikkim	Sudhir Kumar SuhasKhobragade	6 months (11/18 – 04/19)	**Could not be started**
CONSULTANCY PROJECTS:				
SN	**Project**	**Sponsored by**	**Duration**	**Status**
1	Hydro-geological study for Gadarwara super thermal power project, Madhya Pradesh	NTPC	07/15-06/16	Completed
2	Identification of source of seepage in the villages surrounding the Ash Dykes of Barh STPP	NTPC	3 months 03/17 – 06/17	Completed

3	Conservation, remedial and management measures for Nainital Lake	Uttarakhand Irrigation Department	9 months (12/17 – 08/18)	Completed
4	Isotopic and Chemical Analysis of groundwater from exploratory wells installed along paleochannel of Saraswati River Haryana State	WAPCOS	4 months (10/17-02/18)	Completed
5	Hydro-geological study for Darlipali STPP, Odisha	NTPC	9 months (09/15-07/16)	Draft Final Report Submitted
6	Hydro-geological and isotopic study for 1x660 MW Harduaganj PTS, UP	UPRVUNL	12 months (11/15-10/16)	Draft Report submitted
7	Hydrogeological Studies for Dewatering of Jhamarkotra Mines	RSMML	5 years (11/16 – 10/21)	Continuing
8	Pollution source identification using stable isotopic investigations in and around chemical division, GIL, Nagda, MP	NEERI	3 ½ years (10/18 - 03/22)	New Project
9	Validation of the modelling studies for assessing the impact on surface water flow during lean season, due to extraction of 15000 KLD water through proposed RCW on the left bank of River Ganga at Brajghat by Jubilant life sciences limited, Gajraula	Jubilant Life Sciences Ltd., Noida	2 Months (1/19 – 2/19)	New Project (Completed)

ITEM NO. 48.2 ACTIONS TAKEN ON THE ADVICE / DECISIONS OF THE 47th MEETING

No specific action was suggested for any of the studies of the Division, during the 47th working group meeting. Dr. U.K. Sinha, BARC suggested starting a study on isotopic variation in precipitation over India.

ITEM NO. 48.3 PROGRESS OF THE WORK PROGRAM OF THE DIVISION FOR THE YEAR 2018-19

As per the approved work program, the status of studies carried out in HI Division during 2018-19 is given below:

Type of study/Project	*Completed during 2018-19*	*Continuing in 2019-20*	*Total*
Internal Studies	0	0	0
Sponsored Projects	0	6	6
Consultancy Projects	5	4	9
Total	5	10	15

The details of training Courses/Workshops organised by the Division during 2018-19:

S.N.	Title of Training Course/Workshop	Duration	Venue	No. of Participants
1.	Training Workshop on "Interpretation of Isotopic Data for Aquifer Mapping" for CGWB Officials	5 days during 30 July-3 August, 2018	NIH Roorkee	10
2.	Training Workshop on "Interpretation of Isotopic Data for Aquifer Mapping" for CGWB Officials	5 days during 27th August to 31st August, 2018	NIH Roorkee	10
3.	Training Workshop on "Environmental Isotopes for Climate Resiliency of Mountain Watersheds" Government Officials of Nepal.	5 days during 22-26 October, 2018	NIH Roorkee	7
4	Training Workshop on "Coastal Zone Water resources: Challenges Investigation Techniques and Management"	11-15 February, 2019	NIH Roorkee	8

Details of samples analysed by the Division Labs during 2018-19:

S.N.	Parameter analysed	No. of samples
1	$\delta^{2}H$ on DI-IRMS	6996
2	$\delta^{18}O$ on DI-IRMS	919
3	$\delta^{18}O$ on CF-IRMS	5653
4	Tritium	310
5	WQ samples on IC	950

Details of Research Publications by the Division during 2018-19

	Published	Accepted	Communicated
Books/Book Chapter	2	-	-
International Journals	8	4	8
National Journals	-	-	-
International Conferences	3	-	-
National Conferences	-	-	-

Details of important instrument purchased by the Division during 2018-19

S.N.	Name of Instruments	Approximate Cost
1	Normal Scintillation Counter	27 lakh
2	CHNS element analyser	47 lakh
3	DWLR	5 lakh
4	WLR	1.5 lakh

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

Sponsored Projects:

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

Title of the Study:	**Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques**
Study Team:	S. D Khoobragde (P.I.), Sudhir Kumar, Suneel Joshi(Res. Sc-C), Rajesh Singh, M. Arora, R. J. Thayyen and S. K. Verma
Collaborating agencies:	WIHG and HNB Garhwal University
Type of Study:	**S**ponsored (under NMSHE Project)
Funding Agency:	DST, Govt. of India
Budget:	Rs. 177.228 lakh
Date of Start:	April 2016
Date of Completion:	March 2021

Study area

The present study area confined within the geographical coordinates of 29°15’Nto 31°30’Nlatitude and 78°15’Eto 80°15’E longitudes, covering an area of ~21,800 km^2 (Figure 1), it is ~2% of the total drainage area of the entire Ganges River basin in north India [Rao, 1975; Chakarpani et al., 2009]. The Alaknanda and Bhagirathi rivers arethe main tributaries in this region, originatesat higher Himalayas from the snout of the Satopanth and Gangotri glacier [Joshi et al., 1993], respectively.Both the river system drains southern front of the study area and traverses four tectonic discontinuities in the north-south direction [Srivastava et al., 2017]: Southern Tibetan Detachment System (STDS); Main Central Thrust (MCT); Main Boundary Thrust (MBT); and Himalayan Frontal Thrust (HFT).The Bhagirathi river system drains predominantly through dolomitic limestones, quartzites, and metabasic formation, whereas, Alaknanda river system drains through massive quartzites, phyllites, slates, carbonates, and greywackes.The annual precipitation is from ~500 mm/year to ~3000 mm/year in the Himalayan region, whereas the southern front of the mountains in Garhwal Himalayas receives approximately 1400 mm/year (Wasson et al., 2013; Srivastava et al., 2017).

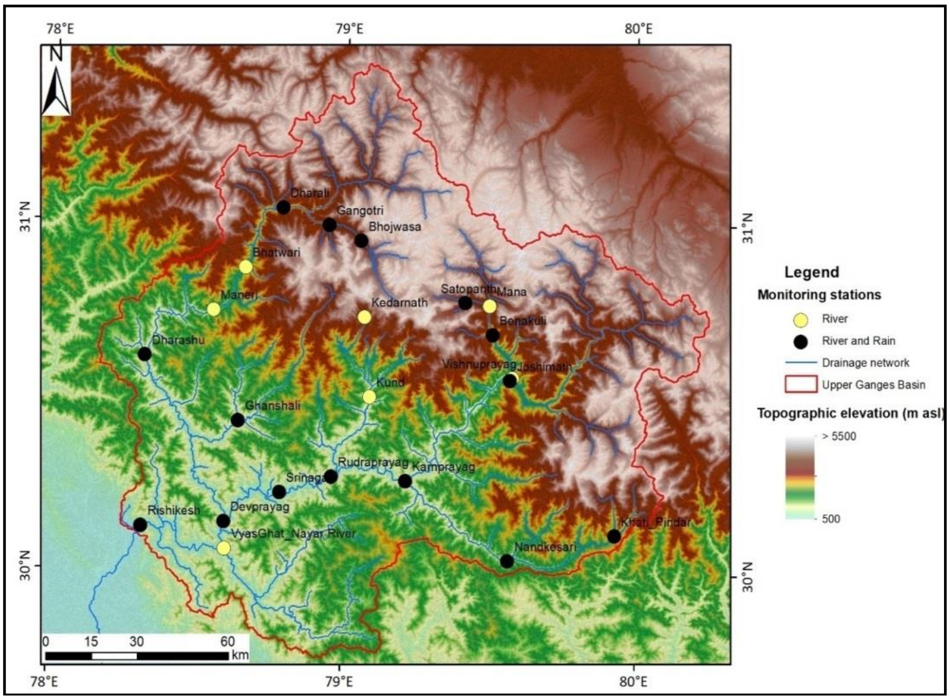


Figure 1: Study area map showing monitoring stations in the Upper Ganges basin

Study Objectives

- Isotopic characterization of precipitation and identification of sources of vapor
- Runoff generation processes in headwater region of Ganga using isotope and modeling
- Spatial and temporal variation of snow and glacier melt in Ganga and its major tributaries.
- The contribution of transient groundwater and its role in the sustainable flow of Ganga.
- Groundwater dynamics in the mountainous area including identification of recharge sources and zones of major springs

Statement of the Problem

The Himalayan mountain system is the source of one of the world's largest supplies of fresh water which is under threat due to severe environmental degradation and climate change. Continuing climate change is predicted to lead to significant changes in the strength and timing of the Asian monsoon, inner Asian high-pressure systems, and winter westerlies – the main systems affecting the climate of the Himalayan region. The impacts on river flows, groundwater recharge, natural hazards, and the ecosystem, as well as on people and their livelihoods, could be dramatically affected, although the effect is not expected to be the same in terms of rate, intensity, or direction in all parts of the region. Therefore, a thorough understanding of hydrological processes operating in Ganga River Basin is essential.

Brief Methodology

- Field survey and site selection for monitoring stations
- Sample collection from various water sources such as precipitation, river, groundwater, snow and ice melt
- Laboratory analysis for stable isotopes, radioactive isotopes, and hydrochemistry
- Isotopic characterization including altitude effect
- Application of two-component isotope model for assessment of the relative contribution of tributaries at confluence points
- Modeling of snow and glacier melt

Action Plan: (2016-2021)

Activities	**1st year**		**2nd year**		**3rd year**		**4th year**		**5th year**	
	I	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**
Appointment of Project staff	√									
Procurement of instruments	√	√								
Literature Collection	√	√	√							
Sample collection and analysis for stable and radioisotopes		√	√	√	√	√	√	√		
Compilation of data, interpretation,and analysis					√	√	√	√	√	
Organization of training course and workshop						√		√		
Preparation of final report										√

Achievement vis-à-vis Objectives

Objectives	**Achievements**
Isotopic characterization of precipitation and identification of sources of vapor	• The sampling of rain from different locations with different altitudes has been carried-out, and analysis is in progress • Altitude effect in Alaknanda basin established
Runoff generation processes in headwater region of Ganga using isotope	• Water samples from river, springs, snow and glacier melt have been collected for isotopic analysis. The

and modeling	analysis is under progress • Spatio-temporal distribution of isotopic composition of river water samples for 9 stations • Snow cover variation in different months during 2005-2016 using MODIS data • Preliminary analysis of the difference in water chemistry of groundwater/springs
Spatial and temporal variation of snow and glacier melt in Ganga and its major tributaries	• To understand the spatio-temporal variability of snow and glacier melt of the study area. A total of 9 sites from upstream to downstream have been established for regular sampling from both Bhagirathi and Alaknanda river basin. • Detailed spatial and temporal variation of stable isotopes and tritium characteristics of Satopanth Glacier (i.e., snow and ice) has been carried out.
The contribution of transient groundwater and its role in the sustainable flow of Ganga	Samples collected for tritium analysis of groundwater, river,and precipitation under laboratory analysis
Groundwater dynamics in the mountainous area including identification of recharge sources and zones of major springs	Isotopic characterization of spring and other groundwaterhas been completed and further analysis for identification of the recharge altitudes is being initiated.

Progress of Work/Results and Analysis

- The monitoring stations (n=21) have been established to collect the water samples from rain and river for stable and radiogenic isotopes. These stations are being monitored by NIH (*n=13*), WIHG (*n=6*), and HNBGU (*n=2*) since 2016. In addition, eight field visits have been undertaken during 2016-2018 by the project staff and additional samples of rain, river, snow/ice, Satopanth glacier, springs and hand pumps have been collected.

- ***Details of samples collected and analyzed till March 2019:***

Parameter	Samples collected	Samples analyzed
$\delta^{18}O$ & $\delta^{2}H$	8800	8500
Tritium	750	147
Chemistry (Major Ions)	482	274

- The geologic and geomorphic maps have been prepared for the study area

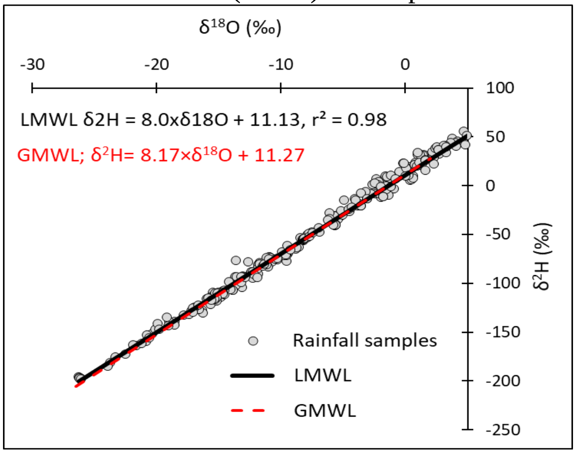
- ***Following analysis has been carried out so far:***
  - Spatio-temporal distribution of isotopic composition of rain and river water samples in the study area
  - Altitude effect for both the river basin (Alaknanda and Bhagirathi)
  - Analysis of stream contribution in Alaknanda and Bhagirathi river system
  - Analysis of groundwater chemistry
  - Linkages of hydrological processes with geomorphic and geologic features in the upper Ganges basin
  - Detailed analysis of the spatio-temporal distribution of Shatopanth glacier
  - Long-term snow covers distribution in different months during 2005-2016 using MODIS data (by WIHG).

Important results obtained so far:

- The isotopic composition of meltwater indicates different vapor sources at Bhojwasa and Satopanth monitoring stations in the upper Ganga basin.
- Seasonal variability has been observed in the isotopic composition of river water at Bhojwasa monitoring station, in Bhagirathi river basin. The $\delta^{18}O$ and $\delta^{2}H$ values showdepleted

signatures during monsoon season and enriched during post monsoon season

- Isotopic composition of snow and Ice shows wide variation at Satopanth glacier. Meltwater shows depleted signatures during the monsoon season.
- Springs and groundwater samples show marked spatio-temporal variation across the study area. Isotopic composition of groundwaters are enriched than the hot springs in the study area.
- Isotopic composition of rain and river water shows altitude wise variation
- Higher electrical conductivity in the upstream region of the study area, particularly in the Tethys Himalayan sequences, is due to the high sediment supply and low water discharge in comparison to the downstream region.
- Seasonal variability has been observed in snowmelt contribution in the Bhagirathi river basin.
- The river contribution at different locations indicates dominant contribution from Alaknanda river basin (~74%) in comparison to the Bhagirathi river basin (~26%) in the study area.



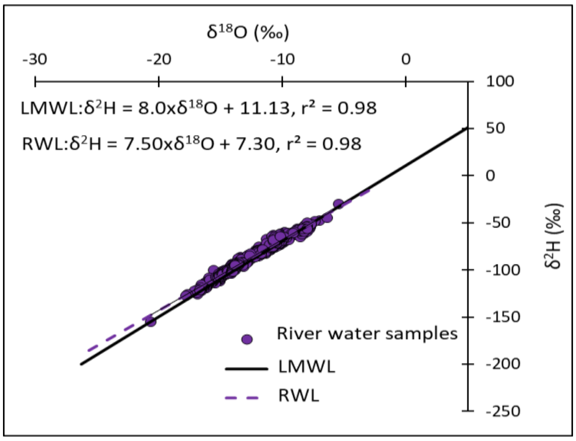


Figure 2. Isotopic composition of rainwaterFigure 3. Isotopic composition of river water

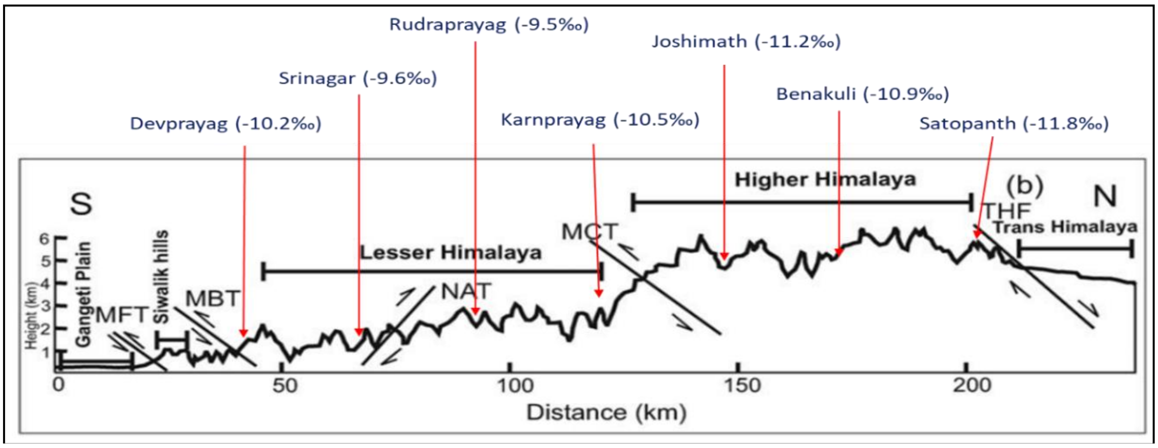


Figure 4Altitude-wise variation in isotopic composition of Alaknanda river water in the study area. Topographic profile of the Alaknanda valley (based on the SRTM-DEM derived data). THF, Trans Himadri Fault; MCT, Main Central Thrust; NAT, North Almora Thrust; MBT, Main Boundary Thrust; MFT, Main Frontal Thrust.

Detailed results shall be presented during the working group meeting.

Future Plan: as per activity schedule

2. PROJECT REFERENCE CODE: NIH/HID/SPON/16-19/GBPIHED

Title of the Study:	**Rejuvenation of springs and spring-fed streams in Mid-Himalayan Basin using spring sanctuary concept**
Study Team:	Sudhir Kumar (PI) and S.K. Verma
Type of Study	**S**ponsored
Funding Agency	G B Pant National Institute of Himalayan Environment and Sustainable Development (GBNIHESD), Almora under NMHS
Budget	Rs. 15.00 Lakhs
Duration:	3 years
Date of Start:	01.06.2016
Date of Completion	31.05.2019

Objectives and Scope of Work:

Environmental Isotope application for study of regional scale altitude effect and recharge zone identification of springs in Lesser Himalaya and Terai regions in Garhwal and Kumaon

Study Area

The study area of Garhwal region of Uttarakhand is a part of PaschimiNayar sub-basin (**Figure 1**) having highest elevation of 2143m to a lowest elevation of 700m.The study area is bounded between latitudes 30°00' N and 30°8' N and longitudes 78°45'E and 78°50'E. Geologically the study area falls in Lesser Himalaya, which ranges between 700-to-2500m high, and is represented by PauriPhyllite and Khirsu Quartzite members of the Maithana formation in the Dudatoli Group.

Analysis and Results

Total 600 water samples, from springs, rainfall and air moisture have been collected from a watershed in Pauri District of Uttarakhand.

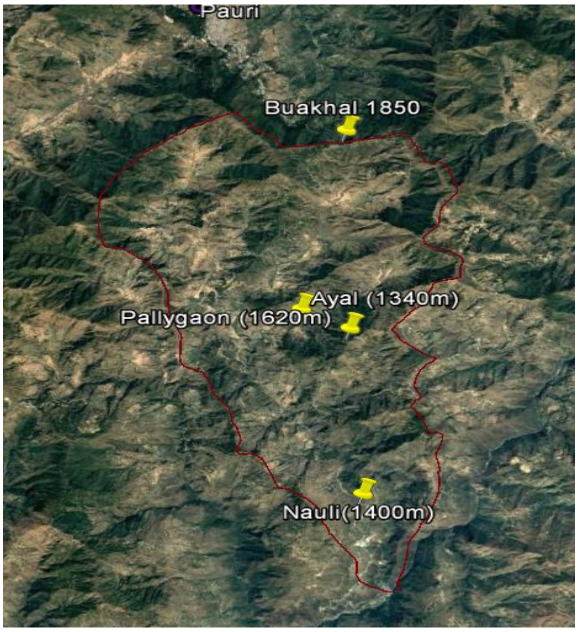


Figure 1: Map of Study Area

The plot of δD and $\delta^{18}O$ from 61 rainfall weekly integrated samples at four different locations within the study area is presented in Figure 2. The regression line drawn between $\delta^{18}O$ - δ D defines the monsoon period local meteoric water line (LMWL) and is represented by the equation $\delta D=7.986\ \delta^{18}O\ +9.976$. The LMWL matches quite well with the regional meteoric water line developed for western Himalaya $\delta D=7.95\ \delta^{18}O\ +11.51$ by Kumar et al. 2010.

d-excess also highlights the high temporal and spatial variability and indicative of recycled/re-evaporated source. The weekly to biweekly samples from the stream (outlet location) and spring falls on the LMWL indicative of common source of origin, i.e. by rainfall recharge.

3. PROJECT REFERENCE CODE: NIH/HID/SPON/16-19/IAEA

Title of the Study:	**Dating vary old groundwaters of deeper aquifers in Ganga Plains, India**
Study Team:	M. Someshwar Rao, (PI), Sudhir Kumar, S.K. Verma
Type of Study	**S**ponsored
Funding Agency	IAEA, Vienna (Austria)
Budget	18,000/- Euros
Duration:	3 years
Date of Start:	01.10.2016
Date of Completion	30.09.2019 (Being extended till March, 2021 by IAEA)

The details are combined with new project "**Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin" (Project No. *NIH-26_2017_62).***

4. PROJECT REFERENCE CODE: NIH-26_2017_62

Title of the Study: Chemical and Isotopic Investigation of Groundwater in Deep Aquifers of Middle Ganga Basin, India

Study Group: Sudhir Kumar, C.K.Jain, M. Someshwar Rao

Collaborating Institution: CGWB (MER, Patna & NER, Lucknow)

Funding Agency: (PDS-NHP)

Budget: Rs. 55.40 Lakhs

Nature of Study: Applied Research

Date of start: January 2018

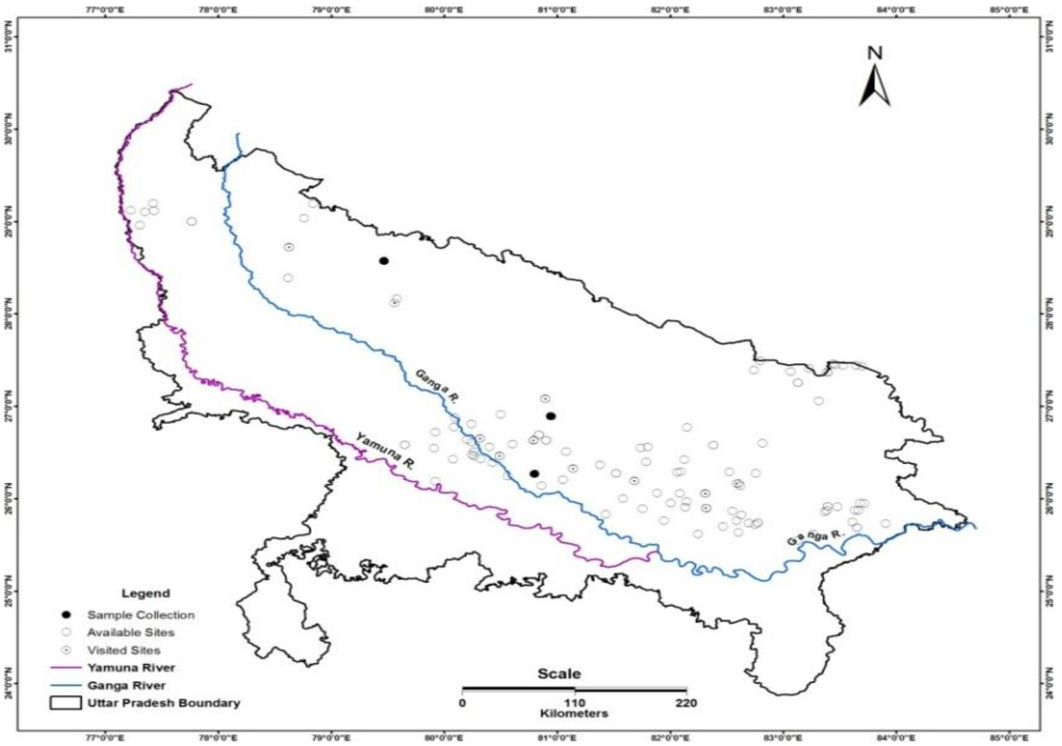
Date of completion: May, 2021

Duration of the Study: $3^1/_2$ Years

Objectives:

i. To identify the various aquifers present in Upper / Middle Ganga Plains.
ii. To identify the source of recharge of deep aquifers
iii. To assess interaction of deep aquifer with overlying aquifers.
iv. Water quality of deep aquifer
v. Sustainability of deep aquifer for its exploration and future use

Study area:

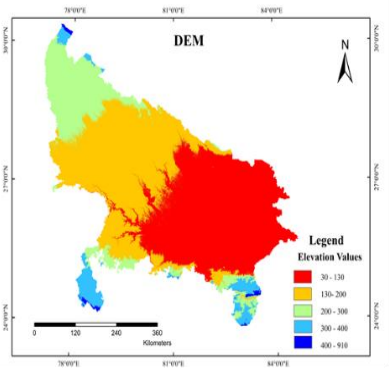


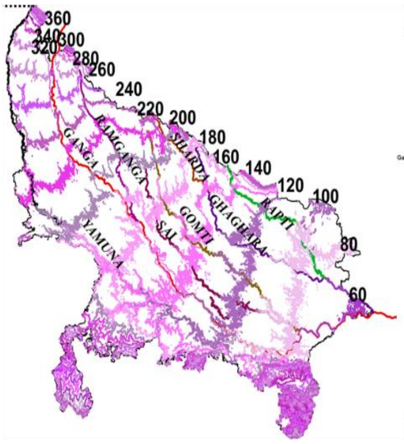
Dist.	Place	Lat	Long	Depth (m)	Well	pH	EC
PRATAPGARH	Laxmanpur	25.89443	81.76116	240-308	W1	7.1	860
	Belharamau	25.89768	82.31265	249-261	W1	7.3	1210
SULTANPUR	Indauli	26.05361	82.30833	249-261	W1		
JAUNPUR	Gairwah	26.16262	82.58585	393-411	W1	8.7	880
	Kurni, Samadhganj	25.69861	82.46389	240-340	W1		
	Leduka	25.86667	82.55	264-340	W1	9	2460
MAU	Banka	25.87222	83.6625	433-484	W1		
	Pijara	25.9111	83.4777	362-459	W1	7.8	800
MORADABAD	Bataua	28.7248	78.61412	265-315	W1	8.1	400
					W2	10.1	600
BAREILLY	PandriHalwa	28.57241	79.46077	279-487	W1	7.4	390
					W2	7.8	460
LUCKNOW	Itaunja	27.08288	80.892	214-435	W1		
	Aliganj	26.89135	80.93986	208-214	W1	7.6	800
	KendriyaBhawan,Aliganj	26.89332	80.94494	337-612	W1		
RAE BARRELI	Anguri	26.32482	81.13851	224-261	W1		
	Pacheri	26.19412	81.67788	312-385	W1		
PRATAPGARH	Belharamau	25.89774	82.31256	249-385	W1		
	Indauli,ThakurBasti	26.05385	82.30633	371-427	W1		
	Indauli, Primary Sch	26.05385	82.30633	371-427	W1		
JAUNPUR	Baba GangdaskiKutiya, Hairwah	26.1624	82.5862	393-489	W1		
UNNAO	Badarka	26.46312	80.48656	287-430	W1		
	Marounda	26.6498	80.31348	295-332	W1		
	Datauli	26.63217	80.78631	214-395	W1		
	Sarai Maniharan	26.26949	80.79364		W1	7.7	1050

The chemical and isotopic analysis of these samples are in progress and the results are expected to get by the end ofMay, 2019.

Sampling of groundwater from deep piezometers from various locations in the middle Ganga Basin, UP Field visit and sample

During the study period, thematic maps of the study area in GIS frame work have also been prepared and these are shown in the figures below:





Digital elevation map and major rivers in the study area

Locations of CGWB wells in the study area

Future Plan: Work Plan & Activity Chart for the period 2019-20

i) Field work to collect the final set of groundwater samples
ii) Tritium and radiocarbon dating of water samples
iii) Water quality analysis of groundwater samples
iv) Preparing aquifer disposition map of the study area
v) Organizing a training programme

5. PROJECT REFERENCE CODE: NHP-NIH-22_2017_38

Title of the Study: Integrated Study on Groundwater Dynamics in the Coastal Aquifers of West Bengal for Sustainable Groundwater Management

Study Group: MS Rao(PI),Sudhir Kumar, ARSenthil Kumar, VSJeyakanthan.

Collaborating Scientist&Institutions:

Er.SubrataHalder, Exe. Eng,State Water Investigation Directorate (SWID), Govt. of West Bengal

Type of Study: Sponsored Project, NHP, MoWR, RD&GR, New Delhi,

Budget: Rs 51.0 Lakhs

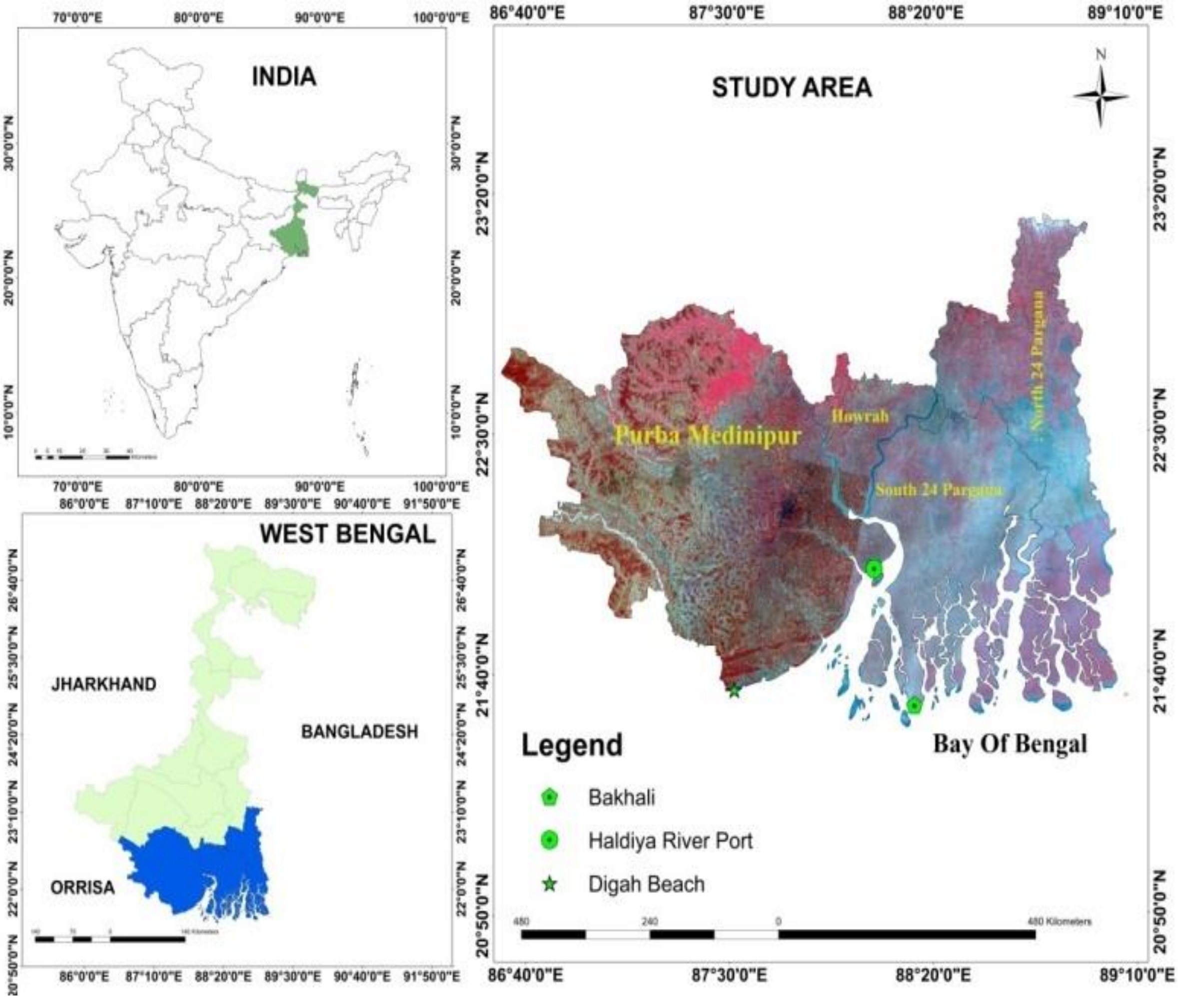
Nature of Study: Applied Research

Date of start: January 2018

Scheduled date of completion: July, 2021

Duration of the Study: $3^{1}/_{2}$ Years

Study area:.



Objectives:

i) Assessment of spatio-temporal variables (sea level change, variation in groundwater levels, rainfall trend etc) influencing dynamics between seawater & groundwater interface using archival data

ii) Spatio-temporal variation map of fresh water – saline water interface from the present observations.

iii) Identification of source of salinity in groundwater
iv) Identification of groundwater recharges sources & flow pattern and temporal and spatial pattern of excess surface water available in the coastal zone for artificial recharge measures
v) Management measures for safe & sustainable coastal groundwater use

Methodology:

i) Preparing review/status report on seawater intrusion (SI) and submarine groundwater discharge (SGD)

ii) Collection and analyzing of archival data influencing SI & SGD processes. This includecollection archival data on change in sea-level, groundwater level data, rainfall data, river stage etc. and, their trend analysis.

iii) **Field work & sample analysis:** Water samples will be collected at uniform frequency for isotopic and chemical analysis (st. isotope, dating, major ion, radon concentration).

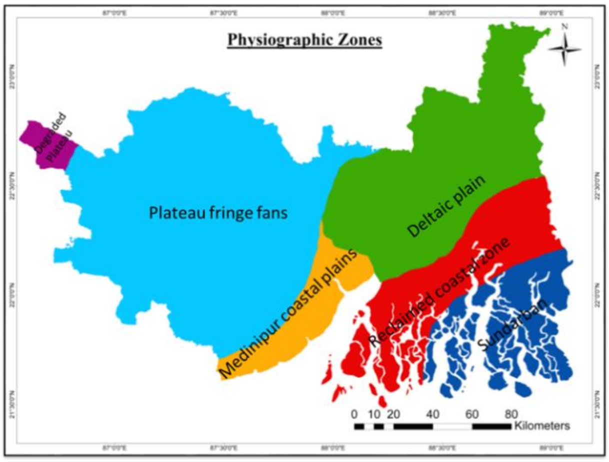
iv) **Data synthesis**: Field data and archival data will be converted into thematic layers on GIS environment. This will provide vulnerable zones for salinization, area experiencing SGD; influence of natural and anthropogenic factors in SI/SGD etc. DEM, optical dataset, land use, soil texture, drainage, groundwater levels (pre & post monsoon), and waterquality data will be used for preparing thematic maps. Data will be analyzed to estimate run-off excess for AR- measures and in controlling SI process.

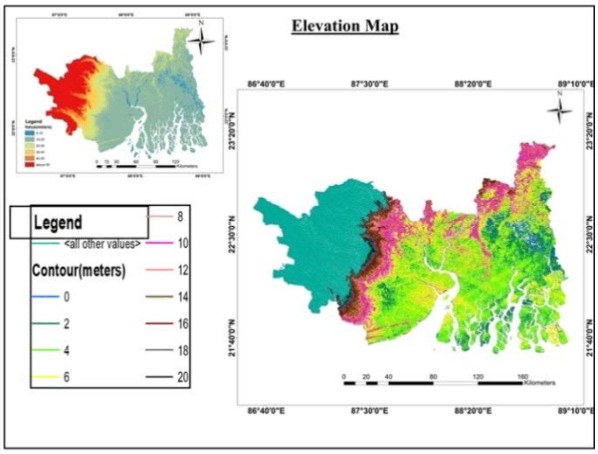
v) **Management Measures:** Data will be interpreted in terms of augmentation of SGD and control over GW salinization.

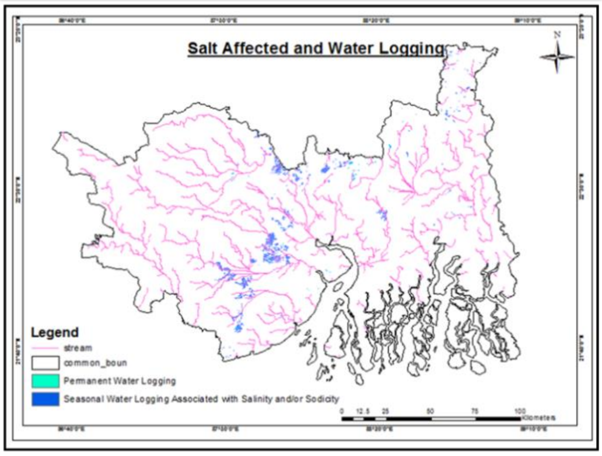
vi) **End use:** (i)Identification of recharge areas, adoptive management strategies for AR-measures, groundwater withdrawal strategies, knowledge dissemination jointly with State Department through mass interactive programmes and brochures in local languages (ii) Review report (iii) DPR will be prepared for field implementable programme.

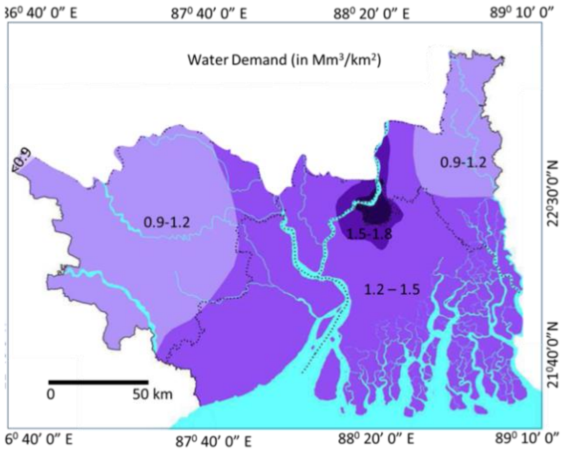
Work accomplished during 2018-19:

1) Prepared various thematic maps (shown in the figs below):

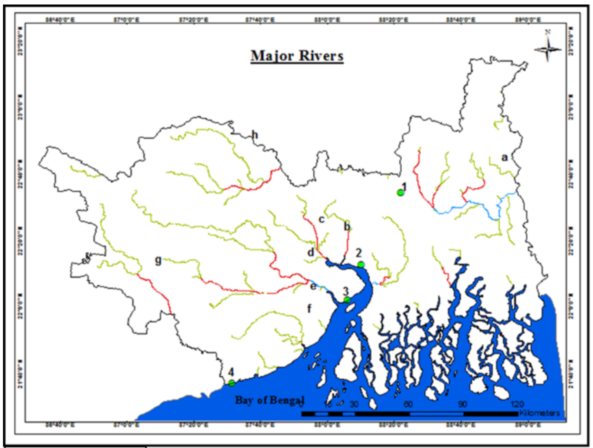


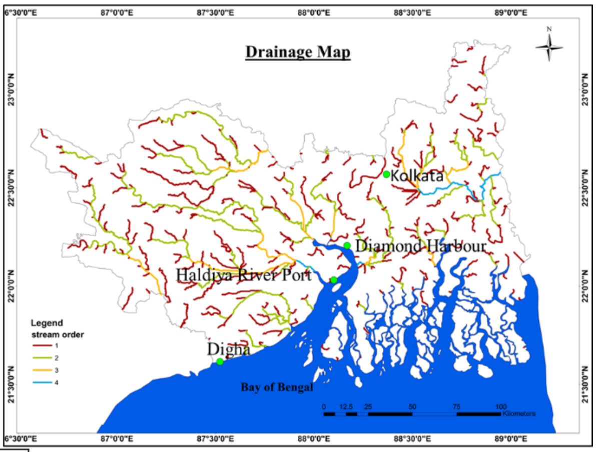






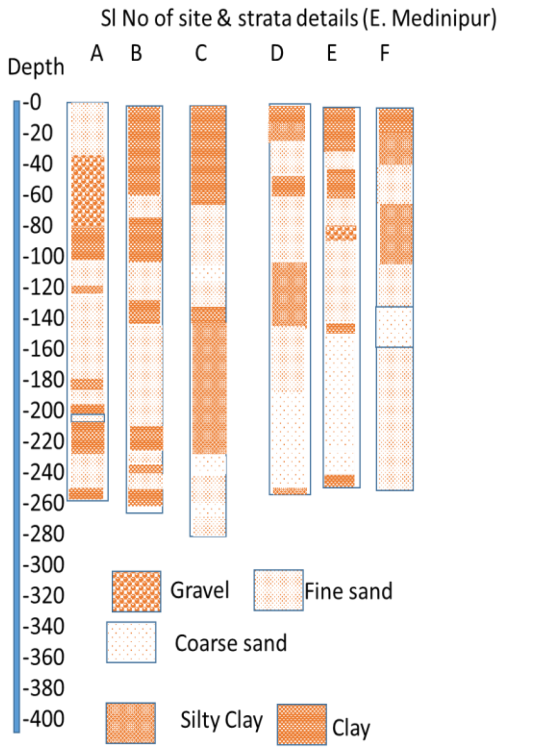
(Source: Bandopadhyay et al, Geol :





	Label	River Name	Length(km)	Label	River Name	Length(km)
1-Kolkata	a	Ichhamati	19.5	a	Ichhamati	19.5
2-Diamond Harbour	b	Hugli	260	b	Hugli	260
3-Haldiya River Port	c	Rupnarayan	80	c	Rupnarayan	80
4-Digha	d	Haldi	24	d	Haldi	24

Piezometers were installedin the field, at various locations and groundwater levels at these locations is being monitored using AWLR (fig shown below).



Sl. No	Site details	Block	Tapped zone (m)
1 (A)	Chandanpur	Ram Nagar	243-252
2	St. Gen. Hosp	Ram Nagar	243-252
3	New Integr. Sch.	Ram Nagar	237-243
4	Maitana GP	Ram Nagar-II	235-241
5 (B)	Bhajachauli GP	Contai-III	259-265
6	Kharzik Barh	Contai III	201-207
7 (F)	Contai BDO Off.	Contai-I	229-235
8	Shyam Raibar	Contai-I	217-223
9 (C)	Baratala Sub HC	Khejuri-II	246-256
10	Cyclone Shelter	Khejuri II	241-247
11	Telpati	Khejuri II	256-278
9 (D)	Birbandar GP	Khejuri-I	219-225
12 (E)	Biruliya 2no-Iry sch	Nandigram-II	223-237
13	Navi Prgti Sangha	Nandigram-II	225-237
14	Debipur	Nandigram-I	234-340
15	Khendamari Iry Sch	Nandigram-I	213-237
16	Deshapran	Deshapran	249-255
17	Krishak Bzr	Deshapran	201-207

Fig: Piezometer with AWLR installed in the field by SWID, GoWB. The tapped aquifer zones at various locations and sub-surface strata details at 5 locations.

Work Element&Time Line:

Sl. No.	Activity	2018				2019				2020				Jan-July 2021	
		1	2	3	4	1	2	3	4	1	2	3	4	1	2
1	Appointment of project staff	✓													
2	Literature survey writing of Status report, review report & interim report			✓	✓	✓	✓	✓		✓	✓	✓	✓		
3	Procurement of items (Datasets,Maps, Instrument,Software)	✓			✓										

4	Database preparation and preparation of various thematic maps		✓	✓											
5	Field survey for water sampling, sample & data collection and monitoring of hydro-meteorological data		✓		✓	✓		✓	✓		✓	✓	✓		
6	Stable isotope, water quality, radon measurement and tritium analysis				✓	✓	✓	✓	✓	✓	✓	✓	✓		
7	Preparing of thematic maps, data analysis & modeling, identification of recharge areas, drawing inferences on coastal hydrological processes and suggesting adoptive measures to improve the groundwater conditions							✓	✓	✓	✓	✓	✓	✓	
8	Publications									✓	✓	✓	✓		
9	Writing of Status report, review report & interim report			✓		✓	✓	✓		✓	✓	✓	✓		
10	Trainings and mass awareness programme					✓			✓		✓		✓	✓	
11	Final report													✓	✓

Work Plan & Activity Chart for the period 2019-20

- Deployment of field staff for sample collection at fortnight interval for isotopic and chemical analysis
- Procurement of data for rainfall – runoff analysis
- Organizing a training programme in the last quarter

6. PROJECT REFERENCE CODE: NIH/HID/NHP/2018-21/1

Title of the Project:	**Development of a Comprehensive Plan for Conservation and Sustainable Management of Bhimtal and Naukuchiatal Lakes,Uttarakhand**
Project team:	S.D. Khobragade (PI), Sudhir Kumar, C. K. Jain and team from IRI, Roorkee
Collaborating agency:	IRI, Roorkee (Lead Organization for NHP PDS)
Type of Study:	PDS under NHP
Duration:	3 years
Date of Start:	1st January, 2018
Date of Completion:	31st December, 2020
Budget:	36 Lakh (NIH)

Statement of Problem:

The lake region of Kumaun Himalaya is known for its biodiversity and socio-economic value. The catchment areas of the Bhimtal and Naukuchiyatal lakes is are hot spots of biodiversity with about 500 species of resident and migratory birds, 20 species of mammals, over 525 species of butterflies and over 11,000 species of moths, beetles, bugs and other insects. Both Bhimtal and Naukuchiatal lakes have traditionally been usedas primary sources of drinking and irrigation water for their regions. However, anthropogenic disturbances in the lake catchment over the last few decades, are threatening the existence of these lakes with problems such as heavy sedimentation, pollution etc. As such, the lakes need a comprehensive conservation plan. The lakes have been identified for conservation under the National Lake Conservation Plan (NLCP) of the Government of India. However, conservation plan for any lake needs proper understanding of the hydrology of the lake ecosystem. Many studies have been reported on the Bhimtal and Naukuchiatal lakes on water quality, ecology and sedimentation but there are no reported hydrological studies. The lakes are owned by the Irrigation department, Uttarakhand who want to rejuvenate the lakes, particularly the Bhimtal and Naukuchiatal, as these are prime sources of drinking water.

Objectives:

i) To assess the seasonal water availability of the lakes and assess its adequacy in meeting future demands
ii) To assess the water quality of the lakes and possible causes of its degradation
iii) To estimate sedimentation rate and expected life of the lake
iv) To suggest a comprehensive conservation and sustainable management plan for the lakes

Brief Methodology

i) Field surveys and field investigations
ii) Bathymetric survey
iii) Collection, processing and analysis of the available data
iv) Generation of additional required data.
v) Preparation of base maps and morphometric characterization
vi) Sample collection and laboratory analysis
vii) Data interpretation and analysis
viii) Assessment of Water balance components, water quality status, sedimentation rates, isotopic characterization

For the assessment of the water balance components, the inflow and outflow and the water level in the lake would be monitored. Lake evaporation would be estimated using Penman-Monteith Method. Groundwater-lake interaction will be studied using conventional technique and isotope technique. Ground water levels in the lake would be monitored. Morphometric characterization and morphological analysis would be carried out using remote sensing and GIS techniques. Lake sedimentation would be studied using bathymetric survey method or isotope techniques. Water quality status of the lake would be assessed from the water quality data of the lake. Water and sediment samples from the lake would be collected and analyzed in the laboratory.

Study Area

Bhimtal is largest lake of all the lakes of Kumaun lesser Himalayan lakes. The lake is situated at 29° 21' N and 79° 34' E at an altitude of 1345 m, amsl. The surface area of the lake is about 0.46 km^2, maximum depth is about 24.7 m and storage capacity is about 5.27 Mm^3. Naukuchiatal is deepest of all the lakes of Kumaun lesser Himalaya. It is situated at 29° 19' N and 79° 35' E at an altitude of about 1320 m, amsl. The surface area of the lake is about 0.30 km^2, the maximum depth is about 42.7 m and storage capacity is about 5.17 Mm^3.and perimeter of the lake is about 3.13 km. The maximum length is about 983 m and maximum width is about 693 m. Both the lakes are significant in terms of drinking water, irrigation requirements, fisheries, recreation and aesthetic values. Due to the various anthropogenic activities (intensive construction and increase in population), the lake and their respective catchments are suffering from various environmental problems, particularly since two decades. The study area is a sub-tropical climate region, with maximum temperature of 32°C during summer (May and June) and minimum temperature below 0°C during winter. The average annual rainfall of the study area is about 1600 mm.

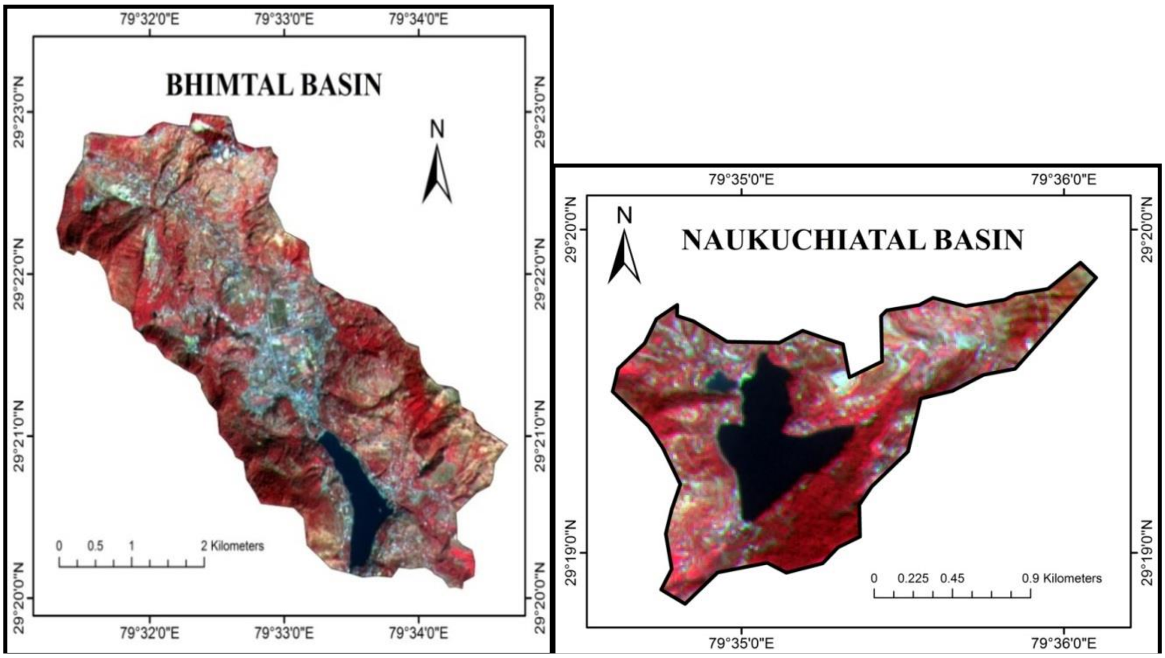


Figure 1: Study area map of Bhimtal and Naukuchiatal lakes

Action Plan: As per activity schedule

Achèvements vis-à-vis Objectives

Objectives	Achievements
To assess the seasonal water availability of the lakes and assess its adequacy in meeting future demands	Hydro-meteorological data required for the purpose is to be generated by IRI, Roorkee. The process is still to be initiated by IRI. However, based on the available data collected by NIH, water balance has been initiated. Isotopic characterization of lake water and surrounding water has been done.
To assess the water quality of the lakes and possible causes of its degradation	Water quality samples have been collected from both the lakes for monsoon and winter seasons of 2018. Analysis has been completed.
To estimate sedimentation rate and expected life of the lake	Bathymetric surveys have been completed for both the lakes and depth area capacity curves have been developed.

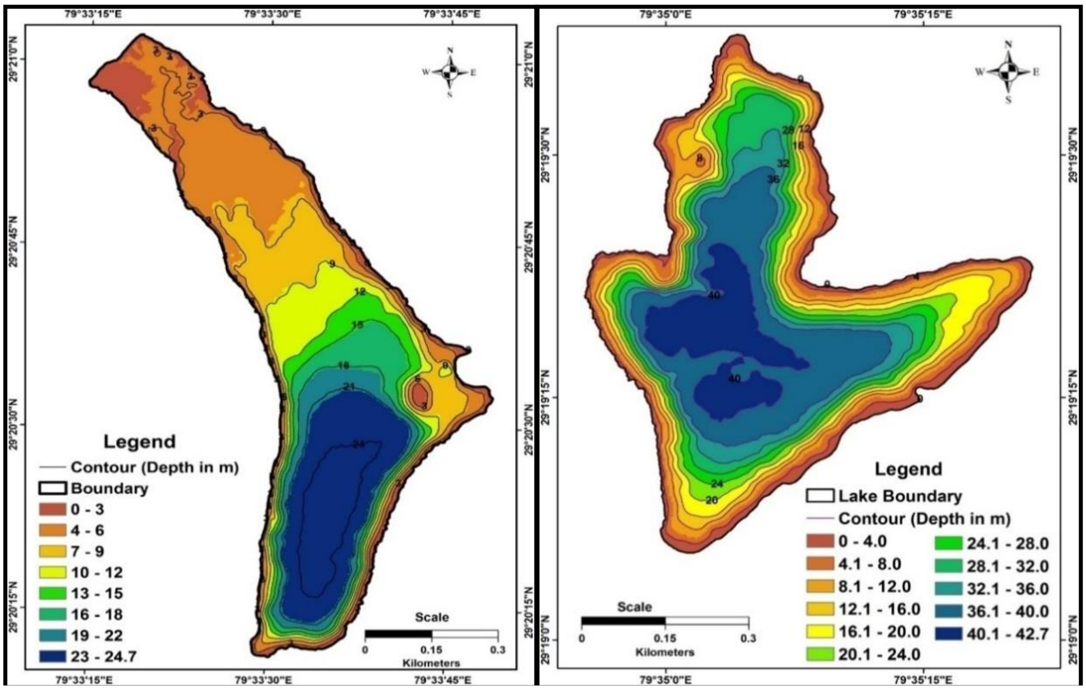
To suggest a comprehensive plan for conservation and sustainable management of the lakes	To be prepared after all the analysis is completed.

Progress of work

- Field visits undertaken during August, September and December, 2018. Water quality and isotope sampling has been completed.
- Bathymetric surveys have been carried out for both the lakes. Depth area capacity curves have been developed.
- 3nos of ORG have been installation, data observes appointed for both the lakes.
- Data on rainfall, pumping and lake levels for the period of 2004 to 2018 have been collected for both the lakes
- Various study area maps such as catchment maps, DEM, land use land cover, drainage map, slope map etc have been prepared.
- Preliminary estimates of lake evaporation obtained using temperature base model.
- Isotopic characterization has been done based on the data obtained so far.
- Groundwater levels have been monitored for post monsoon season.

Important results obtained/Analysis:

i) Bathymetric data indicates that Bhimtallake has a maximum length of 1.7 km, maximum width of 0.48 km, maximum depth of 24.7 m and mean depth of 11.4 m. Te lake has a surface area of 0.46 km^2 and a storage capacity of 5.28 MCM. Naukuchiyatallake has a maximum length of 1 km, maximum width of 0.7 km, maximum depth of 42.7 m and mean depth of 17.3 m. The lake has a surface area of 0.3 km^2 and a storage capacity of 5.17MCM



(a) Bhimtal (b) Naukuchiyatal

Fig. 2: Bathymetric maps of the lakes

ii) The land use and land cover in the catchment area have been broadly classified into seven classes viz., water body, urban, fellow agriculture land, agriculture land, open forest, dense forest and barren land. Open forest has maximum land cover (58-59%) where as Fallow agriculture land has the least land cover (1%) for both the lakes

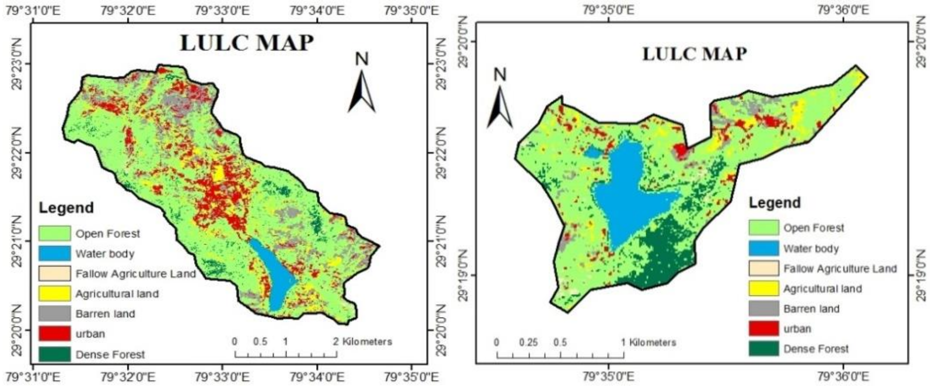
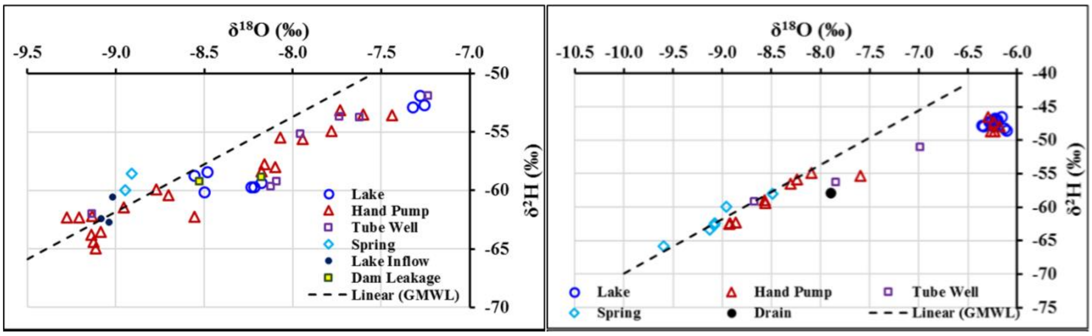


Figure 3: Land use and land cover maps of Bhimtal and Naukuchiatal lake catchment

iii) Isotopic characteristics of Bhimtallake and surrounding indicates that the isotopic signature of upstream groundwater is depleted than lake water as well as downstream groundwater. The isotopic composition of the lake is also showing seasonal effect. Further, recharge source for upstream water bodies is mainly rainwater while the downstream groundwater is getting recharged through lake. In general, lake water is mainly getting recharge through ground water and inflow stream. Isotopic characteristics of Naukuchiyatal are more or less similar to Bhimtallake. Howeer, Bhimtallake the lake is not showing seasonal effect.



(a) Bhimtal (b) Naukuchiyatal

Figure 4: Isotopic characteristics of the Bhimtal and Naukuhciyatallake

iv) Evaporation has been estimated for Bhimtallake using the Hargreaves M-1 for the period of July 2009 to October 2018. It is observed that the evaporation is highest in the month of May, whereas it is lowest during the months of December and January. The average daily evaporation value for entire study period was found to be 2.8 mm d^{-1} and it varied from 1.3 mm d^{-1} to 4.7 mm d^{-1}. The average monthly values ranged between 0.8 mm d^{-1} (December) to 4.8 mm d^{-1} (June).

v) Water quality analysis indicates that Ca^{+} is the major cation in the Bhimtal lake catchment waters. It varies in the range of 64.6 % in tube wells to 70.4 % in hand pumps. Lake, lake inflow and springs are showing Ca^{+} percentage of about 66.2 %, 65.4 % and 65.3 % respectively. HCO_3^- is the major anion. It varies in the range of 80.7 % in lake inflow to 89 % in hand pumps. Lake, tube well and springs are showing HCO_3^- percentage of about 83.3 %, 87.2 % and 86.2 % respectively. This clearly indicates that the water has major effect of regional rock type. The major rocks in the Bhimtal lake catchment are limestoneanddolomitic limestone. Lake and lake inflow has slightly higher percentage of nitrate NO_3^-.

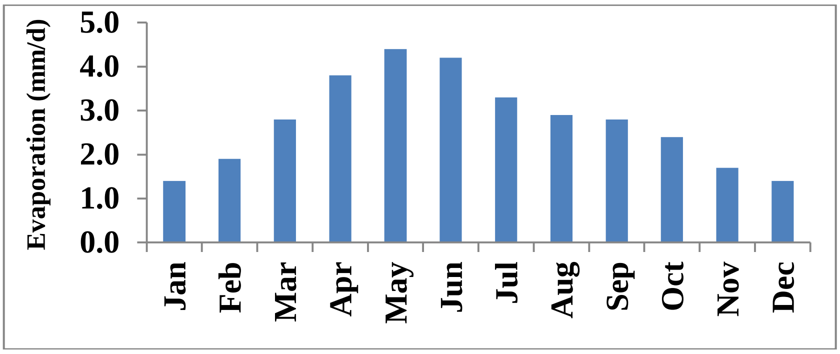


Figure 5: Evaporation rates for Bhimtallake

Detailed results shall be presented in the working group meeting.

Future Plan: as per activity schedule

Activity Schedule: Combined activity schedule of NIH & IRI

SN	Activity	Quarter											
		Year- I				Year- II				Year- III			
		1	2	3	4	1	2	3	4	1	2	3	4
1.0	**PREPARATORY WORK**												
1.1	Reconnaissance survey & finalization of various sampling locations	√											
1.2	Recruitment of project staff	√											
1.3	Collection & Review of all available data/information	√	√	√									
1.4	Compilation of existing data/information	√	√	√	√								
1.5	Identification of Data Gaps	√	√										
1.6	Procurement of instruments and peripherals	√	√	√									
1.7	Purchase of Remote Sensing Data	√	√										
1.8	Purchase of meteorological Data	√	√										
1.9	Installation of equipment in field	√	√										
1.10	Preparation of basic maps of lake and catchment		√	√									
1.11	Installation of piezometers	√	√										
1.12	Arrangement for discharge measurement	√											
2.0	**FIELD WORK**												
2.1	Generation of hydro-meteorological		√	√	√	√	√	√	√	√			
2.2	Collection of water samples for water quality analysis		√	√	√	√	√	√	√	√			
2.3	Collection of water samples for isotope analysis		√	√	√	√	√	√	√	√			
2.4	Collection of sediment samples			√									
2.5	Infiltration tests to determine Infiltration rates			√	√								
2.6	Monitoring of discharge		√	√	√	√	√	√	√	√			
2.7	Bathymetric Survey of lake		√										
2.8	Monitoring of lake water levels		√	√	√	√	√	√	√	√			
2.9	Monitoring of ground water levels		√	√	√	√	√	√	√	√			
3.0	**LABORATORY ANALYSIS**												
3.1	Analysis of samples for Water Quality		√	√	√	√	√	√	√	√			
3.2	Analysis of water samples for isotope characterization		√	√	√	√	√	√	√	√			
3.3	Analysis of sediment samples			√	√								
4.0	**DATA INTERPRETATION & ANALYSIS**												
4.1	Processing of bathymetric data			√	√								
4.2	Development of depth-area-capacity curve for the lake				√								

4.3	Preparation of other maps, morphometric characterization and morphological analysis			√	√								
4.4	Analysis of rainfall and other meteorological data									√			
4.5	Estimation of evaporation losses from the lake										√		
4.6	Assessment of lake-ground water interaction										√		
4.7	Estimation of water balance of the lake										√	√	
4.8	Isotopic characterization of waters of study area									√			
4.9	To develop local meteoric water line										√		
4.10	To estimate sedimentation rate of the lake										√		
4.11	To assess the water quality of the lake			√		√		√		√			
4.12	Assessment of suitability of lake water for various uses											√	
4.13	To develop conservation plan for the lake											√	
5.0	**PREPERATION OF REPORT**												
5.3	Preparation of Interim Project Report				√				√				
5.4	Preparation of Final Project Report												√
6.0	**ORGANIZATION OF TRAINING WORKSHOP**	Post-Project											

New Studies Proposed

PROJECT REFERENCE CODE: NIH/HID/NHP/2019-22/1

Title of the Project: **Integrated hydrological investigations of natural water springs in lesser Himalaya, Uttarakhand**

Thrust Area under XII five year plan

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

Project team: Santosh M. Pingale (PI), Sudhir Kumar,S.D. Khobragade, Soban Singh Rawat, S.K. Bartarya, Rajeev Gupta

Type of Study: Internal R&D study

Duration: 3 years

Date of Start: 1st April, 2019

Date of Completion: 31st March, 2022

Budget: Rs. 31.82 Lakh

Objectives

The present study will be carried out with the following objectives:

1. To inventorize and geo-tagging of the springs in the study area.
2. To characterize natural water springs in respect to different hydro-chemical, lithological, physical and social units. .
3. To develop Intensity-Duration-Frequency (IDF) curves for different return periods of rainfall and characterization of flow duration curves for sustainability analysis of the springs.
4. To assess the impact of anthropogenic activities/climate variability on hydrologic responses of spring's and develop the adaptive measures to sustain the livelihood.

Present state-of-art

The watersheds/springsheds are dynamic and complex systems involving a range of physical processes (natural or anthropogenic) which may operate simultaneously and have different spatial and temporal influences. Understanding those processes is essential for managing the quality and quantity of water availability from both surface runoff and natural springs flow under changing LULC and climatic conditions.The springs form the lifeline for the large part of the population particularly from the most inhabited lesser Himalayan ranges. These natural springs recharge area delineation is essential for protection and management of important spring's water systems. Protection and management of the springs cannot be conducted unless one has a basic understanding of where the relevant lands are located, infrastructure development for water harvesting. Otherwise, it fails in the extreme events of rainfall, causes stresses during dry season as well as drying of springs due to anthropogenic activities and climatic changes need to be understood for taking adaptive measures.

The accurate information and response of natural springs from different geological settings (i.e., lithological units) under variable climatic and LULC change conditions are needed for sustainable development and management of natural springs in the lesser Himalayan watersheds.It is also important to address the various model uncertainties and address it properly in hydrological modeling studies.

Study area: The present study will be carried out for the selected springs in the Tehri-Garhwal district of Uttarakhand(Fig. 1).

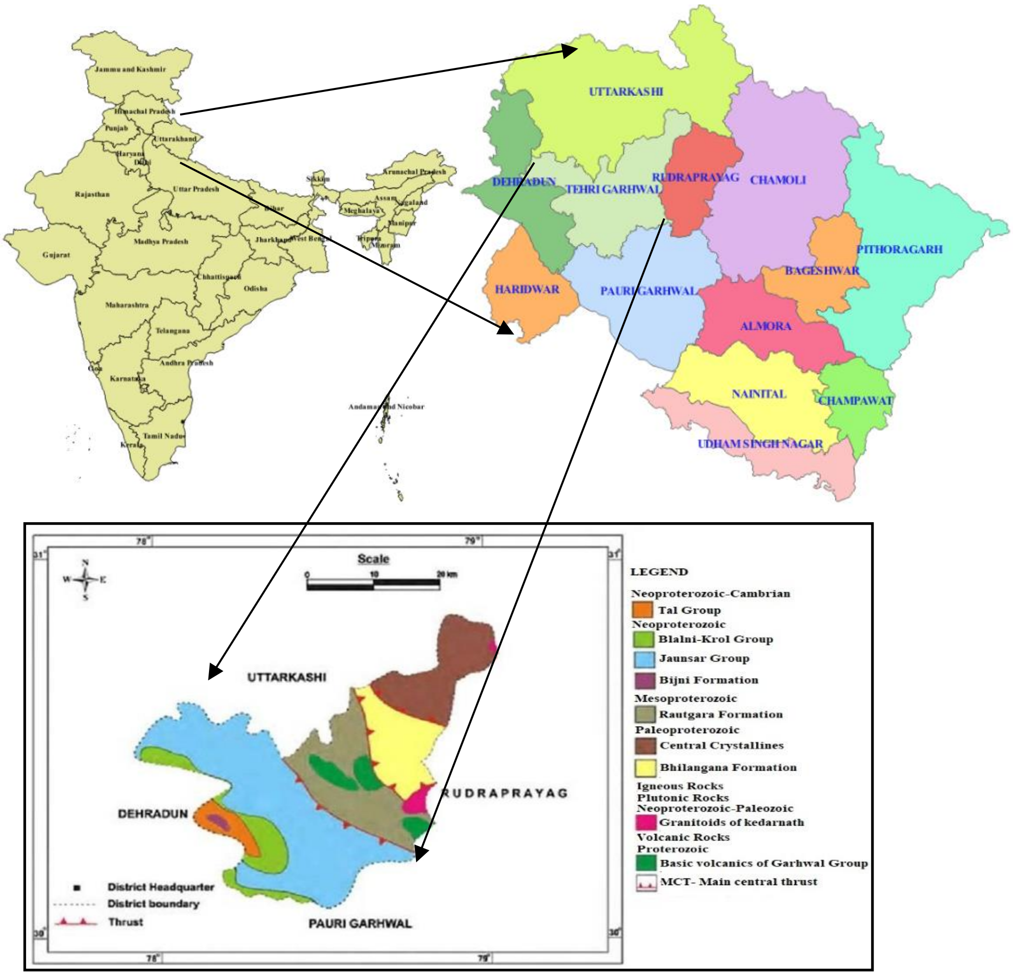


Fig. 1 Location of the proposed study area(Source: Soil and Land Use Survey of India, 2019)

Methodology

The framework of the proposed methodology has been given in Fig. 2 and subsequently described here:

a. The comprehensive GIS-based inventory and mapping of available natural springs will be carried out in the study area.

b. Geo-database will be created for the springs which can be updated time to time..

c. The representative springs from different lithological units will be selected for continuous monitoring hydro-chemical, physical and social parameters (e.g. Discharge, pH, EC, TDS, major anion and cation), dependent population, use of water and land use conditions around the spring’s sources/springsheds/watersheds.

d. The characterization of spring in different lithological units will be carried out using hydrological investigation techniques involving isotopic and chemical characteristics.

e. The trends and shifts in hydro-climatic variables using different statistical techniques (e.g., Mann-Kendall (MK), Modified MK testand Pettit’s Mann-Whitney test) and LULC change will be undertaken for the selected study area.

f. The characterization and development of Intensity-Duration-Frequency (IDF) curves for rainfall and Flow Duration (FD) curves of the water springs will be undertaken to assess the sustainability of available water resources for the selected springs.

g. The impacts of anthropogenic activities and climate variability on selected natural springs flow in different lithological units within the watershed/springshedwill be identified.

h. Finally, suitable interventions and scaling out plan will be suggested based on hydrological investigations.

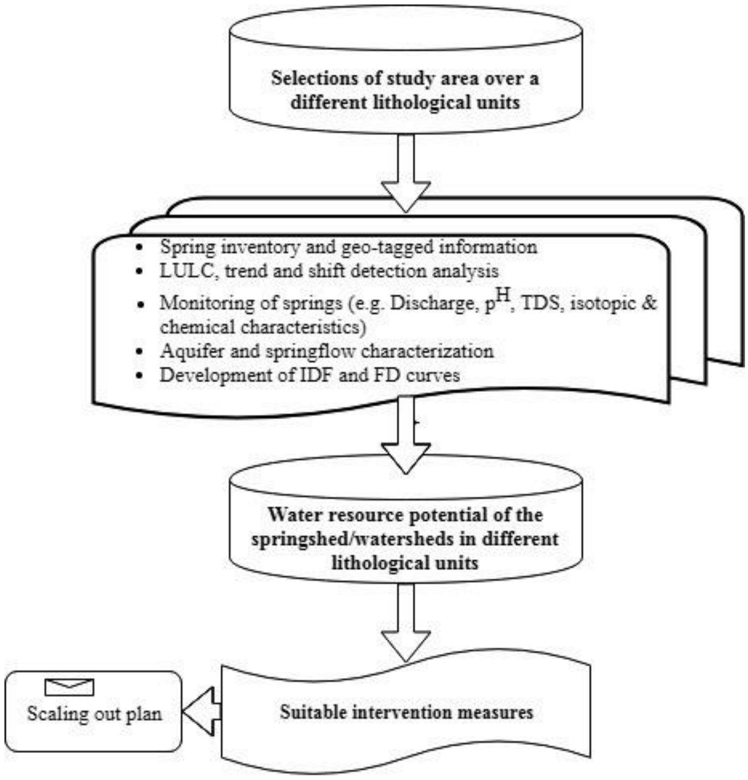


Fig. 2 Flow chart of methodology to be adopted in the proposed study

Research outcome from the project

- ✓ Availability of natural springs inventory and its geo-database for planners, community and various stakeholders for developmental activities in the study area.
- ✓ Springflowcharacterization and natural resource potential of the watershed/springsheds will be identified in different lithological units.
- ✓ The quantification of any significant shifts and trends in hydro-climatic variables and LULC change in the selected study area.
- ✓ Development of IDF curves, which can be used in the climate-smart/sustainable design of hydrologic, hydraulic, and water resource systems; and flow duration curves, which can be used for estimation of dependable flows for water availability and distribution planning in the study area.
- ✓ The response of springs to anthropogenic activities/climate variability over different lithological units will be quantified.

Budget estimates

a. The total cost of the project: **Rs. 31.82 lakh**
b. Source of funding: Internal funding from NIH and will try to get external funding
c. Sub Headwise abstract of the cost

S.N.	Sub-head	Amount (in Rupees)
1	Salary (Field staff)	4,32,000
2	Travel	12,00,000
3	Equipment	13,00,000
4	Experimental charges/data	1,00,000
5	Others (contingency, consumables)	1,50,000
	Grand Total:	**31,82,000.00**

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

Salary: Full time **FOUR field personnel's**(@3000/month for three years) for continuous collection of discharge data and monitoring of field equipments at the selected project sites.

Travel: Extensive field work would be essential for regular hydro-geological data collection, monitoring of sites and ground truth survey in the study area

SN	Travel	No. of persons	Total
1	DA	4	3,00,000
2	Accommodation	4	4,00,000
3	Porter	3	1,20,000
4	POL/Taxi	Lump sum	3,30,000
5	Contingency		50,000
		Total	**12,00,000**

Note: Calculated for100 days offieldwork in 3 year(60 days in first year and, 20days in second and third year)

Equipment: The required data will be procured from IMD, NRSA and other State government agencies. In addition, Automatic weather station (02), Automatic Water Level recorder (04) and other minor instruments (e.g. Weirs, notches,tipping bucketsetc) have been planned to purchase for carrying out detailed study.

SN	Items	Quantity	Unit cost	Total Cost
1	Automatic Weather Station	2	2,00,000	4,00,000
2	Automatic Water Level Recorder/automatic discharge level measurement gauge	4	1,00,000	4,00,000
3	Other minor instruments (e.g. Weirs, notches, tipping buckets, ORG etc.)	Lump sum		5,00,000
			Total	**13,00,000**

Work Schedule:

d. Probable date of commencement of the project: March, 2019
e. Duration of the project:03 Years
f. Stages of work and milestone:

S. N.	Work Element	1st Year				2nd Year				3rd Year			
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
1	Data collection (e.g. hydro-meteorological data, satellite imageries, thematic data)												
2	Inventorisation and geo-tagging of natural springs in the selected study area												
3	Monitoring of selected spring discharge												
4	Collection and analysis of water samples for water quality and isotope for delineation of spring recharge areas												
5	Springflow characterization												
6	LULC analysis												
7	Trend/shift detection in hydro-climatic variables for the selected springs under watersheds												
8	Characterization & development of IDF and FD curves												
9	Report writing												
10	Dissemination of results/ Scaling out plan												

PROJECT REFERENCE CODE: NIH/HID/NHP/2019-22/2

Title of the Project:	**Isotope fingerprinting of precipitation over Indian Region**
Thrust Area:	R&D under NWM (Implementation of modern technology for measurement of various data)
SDG target:	Change in extent of water related ecosystems over time (6.6.1)
Study team:	NidhiKalyani**(PI)**, Dr. Sudhir Kumar, M.S. Rao, Swapnali Burman, N.G. Pandey, S.S. Rawat, R.K. Jaiswal, M.K. Jose, T. Vijay
Type of Study:	Internal R&D study
Duration:	3 years
Date of Start:	1stApril, 2019
Date of Completion:	31stMarch, 2022
Budget:	31.82 Lakh

Rationale: Precipitation stable isotopes can be used to trace the water cycle and to interpret paleo-climatic archives. Forecasts of natural and anthropogenic impacts on climate require a better understanding of factors controlling regionalized precipitation regimes. This is especially important in tropical areas, where the complexities of atmospheric circulation and water cycle's seasonal intensity limit our capability to predict changes in precipitation patterns and water availability. This project will focus on present day isotope information in precipitation and its use for interpretation of validation of hydro-climatic phenomenon and models respectively. The data will be compared with already available isotope data available from various paleo-climatic archives to better inform climate models.

Objectives:

Major Objective of the project is to better assess impacts of climate change on water resources variability, availability and sustainability by use of environmental isotopes.

The specific objectives shall be

- Improve interpretation of past climate archives such as speleothems, lake sediments, ice cores, tree rings etc. using environmental isotopes in order to better understand regional and local climate dynamics and their possible impact on water resources at present and in the future.
- Improve regional climate and water balance model outputs using present day precipitation/ vapor isotope data.
- Initiate/consolidate daily and/or event based monitoring programs of precipitation stable isotopes.
- Review/assess the level of understanding of links between stable isotopes and various factors that control them in tropical regions at different spatial and temporal scales.

Present state-of-art

The International Atomic Energy Agency (IAEA) and the World Meteorological Organization (WMO) runs worldwide isotope monitoring network of hydrogen and oxygen isotopes in precipitation -The Global network of isotopes in precipitation (GNIP) since 1960. This data is extensively used as a key tracer in hydrology, hydro-climatology and paleo-climatology studies. The stable isotopic characteristics of Indian precipitation was studied in the context of geographical and meteorological conditions and the associated atmospheric processes for several Indian regions (northern India, southern India and Himalayan region) during the period 2003-2006 and the Indian Meteoric Water Line was established_. Atmospheric moisture content was examined for Indian monsoonal patterns_. Several other researchers across the world have studied characteristics of isotopes in precipitation and atmospheric water vapor, eminent work being Dansgaard(1964), Craig and Gordon(1965), Jacob et. al.(1991) and Rozanskiet.a al. (1993).

Methodology

The envisaged objectives will be achieved through –

a. Establishing of precipitation isotope monitoring stations at following sites across India:

1.	Roorkee	2.	Patna	3.	Kolkata
4.	Guwahati	5.	Bhopal	6.	Jammu
7.	Srinagar	8.	Mangalore	9.	Kakinada
10.	Bangalore	11.	Bombay	12.	Thiruvananthapuram

b. Sampling of precipitation isotopes and laboratory analysis for investigations of deuterium and ^{18}O content in precipitation.
c. Spatiotemporal mapping of D and ^{18}O values in precipitation samples for hydrological investigation studies.
d. Identification of the role of geographic, meteorological and atmospheric circulation /Indian monsoon in the space-time variations of isotopic composition of precipitation over Indian region.
e. Application of available data on isotopic composition of precipitation for parameterization of processes in Global Circulation Models, which influence isotope composition in precipitation.
f. Continuation of collection and analysis of stable isotope data over established networks.
g. Identification of climate signals in isotopic composition of precipitation (Climatic variables such as temperature have shown good correlation with isotopic composition of precipitation) to improve interpretation of paleo-climatic archives.

Research outcome from the project

The output of the study would be in the form of a comprehensive report. The report would contain all hydro-meteorological data and isotopic composition of precipitation samples at different locations across India. It would provide temporal and spatial variations of environmental isotopes in precipitation (oxygen-18 and deuterium) over India for use in hydrological investigations studies and identify the role of Indian monsoon and/or hydrological cycle in determining the space-time variations of isotopic compositions in precipitation. Model parameterization of global circulation models will be done using observed isotope signals to better simulate regional climate dynamics for hydrological studies. A continued program would attempt to identify climatic signals in isotopic composition of precipitation for paleo-climatic studies.

Budget estimates

a. The total cost of the project: **Rs. 20.00 lakh**

b. Source of funding: Internal funding from NIH

c. Sub Headwise abstract of the cost

S.N.	Sub-head	Amount (in Rupees)
1	Salary (Field staff)	6,48,000
2	Travel	3,00,000
3	Equipment	6,00,000
4	Experimental charges/data	2,00,000
5	Others (contingency, consumables)	2,52,000
	Grand Total:	**20,00,000**

d. Details of Budget components

Justification for Sub-head-wise abstract of the cost

Salary: Full time **SIX field personnel's** (@3000/month for three years) for regular precipitation sampling.

Travel: Required for sample collection and other data collection

Equipment:

SN	Items	Quantity	Unit cost	Total Cost
1	Automatic Raingauge with collector system	6	1,00,000	6,00,000

Work Schedule

S N.	Work Element	First Year				Second Year				Third Year			
		1-Qtr	**2-Qtr**	**3-Qtr**	**4-Qtr**	**1-Qtr**	**2-Qtr**	**3-Qtr**	**4-Qtr**	**1-Qtr**	**2-Qtr**	**3-Qtr**	**4-Qtr**
1.	Recruitment of project staff	√	√										
2.	Literature Review	√	√			√				√			
3.	Collection and compilation of all available data/information	√	√										
4.	Establishing of network of station for precipitation isotope sampling	√	√	√	√								
5.	Sample Collection and transportation	√	√	√	√	√	√	√	√	√	√		
6.	Laboratory Analysis of samples for isotopic composition			√	√	√	√	√	√	√	√	√	
7.	Space-time mapping of isotope composition in precipitation samples				√	√	√	√	√	√	√	√	
8.	Application of data/maps for study of Indian monsoon and hydrologic cycle					√	√	√	√	√	√	√	
9.	Assessment of climate change signals in isotope composition								√	√	√	√	
10.	Preparation of interim report				√				√				
11.	Preparation of final report												√

SURFACE WATER HYDROLOGY DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. Rakesh Kumar	Scientist G & Head
2	Dr. A K Lohani	Scientist G
3	Dr. R P Pandey	Scientist G
4	Dr. S K Singh	Scientist F
5	Dr. Sanjay Kumar	Scientist E
6	Dr. Archana Sarkar	Scientist D
7	Dr. L N Thakural	Scientist C
8	Sri J P Patra	Scientist C
9	Dr. Ashwini A. Ranade	Scientist C
10	Sri Sunil Gurrapu	Scientist C
11	Sri N K Bhatnagar	Scientist B
12	Sri Waikhom Rahul Singh	Scientist B
13	Sri Om Prakash	SRA
14	Sri Jatin Malhotra	SRA
15	Sri T R Sapra	RA

WORK PROGRAM FOR THE YEAR 2018-19

ONGOING STUDIES(Sponsored)			
1.NIH/SWHD/NIH/16-21	Hydrological modeling in Alaknanda basin and assessment of climate change impact	A.K. Lohani Sanjay K. Jain Archana Sarkar V.S. Jeyakanthan L.N. Thakural	**Sponsored by NMSHE** 5 years (April 2016 to Mar. 2021)
2.NIH/SWHD/NIH/17-20	Water efficient irrigation by using SCADA system for medium irrigation project (MIP) Shahnehar	R.P. Panday J.P. Patra Rajesh Singh N.K. Bhatnagar	**PDS under NHP** 3 years (Dec 2017-Dec 2020)
3.NIH/SWHD/NIH/17-19	Impact Assessment of Climate Change on Water Resources and Agriculture in Banas basin in Western India using Climate change Indicators (CII's). Approval for signing the sub-contract with SMHI and transfer of funds to NIH has not been received. Therefore, NIH continues in the consortium as "In Kind Partner". The objectives of CII development and script writing will be taken up by the core team at SMHI with help from NIH.	Archana Sarkar Surjeet Singh T. Thomas	1.5 years (Sep. 2017 to Feb. 2019)
4.NIH/SWHD/NIH/14-18	Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India	Ashwini Ranade	**Sponsored by SERB-DST** 4 years (Oct. 2014 to Nov. 2018)
ONGOING STUDIES (Internal)			
5.NIH/SWHD/NIH/17-21	Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin Subzone 3(f)	Sanjay Kumar Rakesh Kumar J. P Patra Pankaj Mani	4 years (April 2017 to March 2021)
6.NIH/SWHD/NIH/15-19	Study of Hydrological Changes in selected watersheds in view of climate change in India	L.N. Thakural D.S. Rathore Surjeet Singh Sanjay Kumar Jain Sharad Kumar Jain	4 years (April 2015 to March 2019
7.NIH/SWHD/NIH/17-20	Development of regional methods for design flood estimation in Uttarakhand	J.P. Patra Rakesh Kumar Pankaj Mani Sanjay Kumar	3 years (April 2017 to March 2020)
8.NIH/SWHD/NIH/18-21	Evaluation of seasonal extreme rain events across river basins of India in 3D global temperature change scenario	Ashwini Ranade Archana Sarkar	3 years (April 2018 to March 2021)
NEW STUDIES			
9.NIH/SWHD/NIH/18-20	Assessment of climate change impact on water availability and agriculture in part of Banas basin	Archana Sarkar Surjeet Singh Suman Gurjar Sunil Gurrapu	2 years (Nov 2018 to October 2020)

10.NIH/SWHD/NIH/18-21	Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent	Sunil Gurrapu Ashwini Ranade J.P. Patra	3 years (Nov 2018 to March 2021)
11.NIH/SWHD/NIH/18-20	Evaluation of Water Quality of Government Schools in Roorkee Block, District Haridwar	N. K. Bhatnagar M. K. Sharma L. N. Thakural Reena Rathore	2 years (Oct 2018 to Sep. 2020)

1. Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India

PROJECT REFERENCE CODE: NIH/SWD/14-18

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

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

Role of Team members: completion of the project successfully

Type of Study: Sponsored Research

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

Budget sanctioned: 12.6 lakh

Date of Commencement: 17 October 2014

Date of completion: 25 Nov 2018 (Completed)

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

Objectives:

Sr. No.	Objectives	Achievements
1.	To investigate underlying mechanism of intensification and weakening of Asia-Pacific monsoon circulation intensity in the backdrop of heterogeneous global temperature change.	Completed
2.	Determination of commencement and cessation dates of monsoon circulation and start and finish of monsoonal rains.	Completed
3.	To understand structure of the monsoon circulation associated with large-scale extreme rain events over and across India.	Completed

Statement of the problem:

Monsoon is one of the oldest observed weather phenomena noticed by seafarers globally. It is the prime weather system for the summer seasonal rainfall in tropical Asia-pacific region. The strongest monsoon is encompassed in the Indian sector. Several theories have been proposed so far based on wind direction, precipitation, and circulation for the explanation of the origin, the life cycle and the genesis of the monsoons across the world. In India, the start and finish dates of the monsoon rains and occurrences of large-scale heavy rain events are valuable information for the agricultural and water resource management. Several criteria have been proposed so far based on the meteorological parameters (wind, relative humidity, OLR, etc.) along with rainfall; parameters other than rainfall or only with rainfall to determine the start and finish of monsoon rains over different parts of the monsoonal regime. Most of the objective criteria suggest climatological onset and withdrawal dates or onset date for Kerala only. Dates for the advancement of monsoon across the country is still not resolved satisfactory. Extreme rain events during the monsoon season, show unusual characteristics in respect of variability in the location, frequency, intensity and areal extent. Sometimes they occur in very isolated location and during the period, when most part of the country was under dry condition. In recent decades occurrences of unusual, unprecedented or extreme weather events were generally attributed to global warming. Attempts have been made to understand underlying mechanism of the weather systems those produced extreme rain events (EREs). Understanding of the underlying mechanism for their occurrences on case by case basis are pivotal in severe weather alerts, water resources and agricultural advisories.

This project work covers an elaborate account of the hydro-meteorological studies of the occurrence of Asia-pacific monsoon circulation and criteria for the start and finish of monsoon circulation and monsoon rains over India. User's friendly meteorological analysis technique has been suggested for the understanding of the dynamics of the occurrences of heavy rain events. Two case studies of extreme rain events (23-28 July 2005 and 16-17 June 2013) are studied in details in order to understand the monsoon circulation associated with large-scale extreme rain event and small scale, short duration intense rain spell.

Analysis and Results:

Routine observations of real-time daily weather charts revel that, large-scale atmospheric general circulation parameters show significant transformations in their values from one season to another. The annual cycle of the global atmospheric parameters (e.g. temperature, mean sea level pressure, geopotential height and thickness, the wind, Precipitable water etc.) are studied in details during six different times of the year (end of January, end of March, end of May, end of July, end of Sept and end of Oct). NCEP Climate Forecast System Reanalysis (CFSR) 6 hourly products from 1979-2016 at 2.5X2.5 degree resolution (Temperature, Geopotential height, U and V wind at 12 isobaric levels, Mean sea level pressure, and Precipitable water) and 0.25 degree gridded rainfall data from India Meteorological department are used in this study.

1. Determination of start and end of monsoon circulation and monsoon rains across India

We understand that, Monsoon evolves in association with spreading and intensification of equatorial atmospheric condition (warm-moist-low pressure with lower tropospheric convergence and warm-high upper tropospheric divergence). So combinations of equatorially-conditioned (difference from corresponding equatorial value) atmospheric parameters were used to locate the area under monsoon condition on any day of the year across globe and for the development of criteria for the start and end of monsoon circulation over 19 subdivisions of India during 1979-2013. A structured five level approach has been suggested for the development of the criteria to determine robust start and end dates of monsoon circulation and monsoon rains over 19 subdivisions of India.

(1) Quantitative determination of start and end of effective global atmospheric condition:
Tropospheric temperature-thickness index (TZI) has been developed. Effective summer over NH, winter over SH, effective NH-SH contrast and effective warming over the Tibet are said to be attended when the corresponding TZI exceeds ±0.5. The latest start of the above four seasonal transitions are considered as the date for the robust effective start for the effective global atmospheric thermal structure (EGATS), and earliest of above four dates as robust effective finish of the EGATS.

(2) Qualitative analysis of charts showing global weather regimes (GWRs), streamlines and globally-conditioned wind speed (difference from global mean)
Global weather charts showing four different types of GWRs (combination of equatorially conditioned temperature and geopotential height), streamlines and GC-wind speed at different isobaric levels are monitored on daily basis in order to mark the area under warm-moist-low pressure area with lower tropospheric convergence and warm-high upper tropospheric divergence representative of arrival of monsoon circulation.

(3) Qualitative analysis of charts showing area under effective Indian monsoon condition
Area under monsoon condition across the globe on daily basis has been demarcated after the satisfaction of the more than intense equatorial values of lower tropospheric temperature (1000-700hPa), EC-T_{LTT} >0; precipitable water, EC-PPW >0; pressure, EC-mslp < 0; and 600 hPa geopotential height, EC-Z_{600} <0.
Continuous real-time monitoring of the area under monsoon condition across the globe are helpful to determine robust dates for start and end of effective monsoon circulation and monsoon rains over different parts of the country. Fig.1 shows the normal area under monsoon condition,

superimposed on 600-hPa streamlines across Indian subcontinent during monsoon season.

(4) Quantitative determination of commencement and cessation of Indian monsoon condition over 19 subdivisions across India
Latest date of the accomplishment of the four criteria mention in stage 3 individually for each subregion gives the start date for the commencement of Indian monsoon condition and non-occurrence of the above along with the monitoring of the ATS qualitatively marks the cessation date of monsoon activity over a particular subregion.

(5) Quantitative determination of start and end dates of Indian monsoon rains across 19 subdivisions.
After satisfaction of the all above conditions, region specific purpose driven (agricultural, hydrological, meteorological etc.) rainfall threshold can be used for the determination of start and end dates of effective monsoon rainfall.

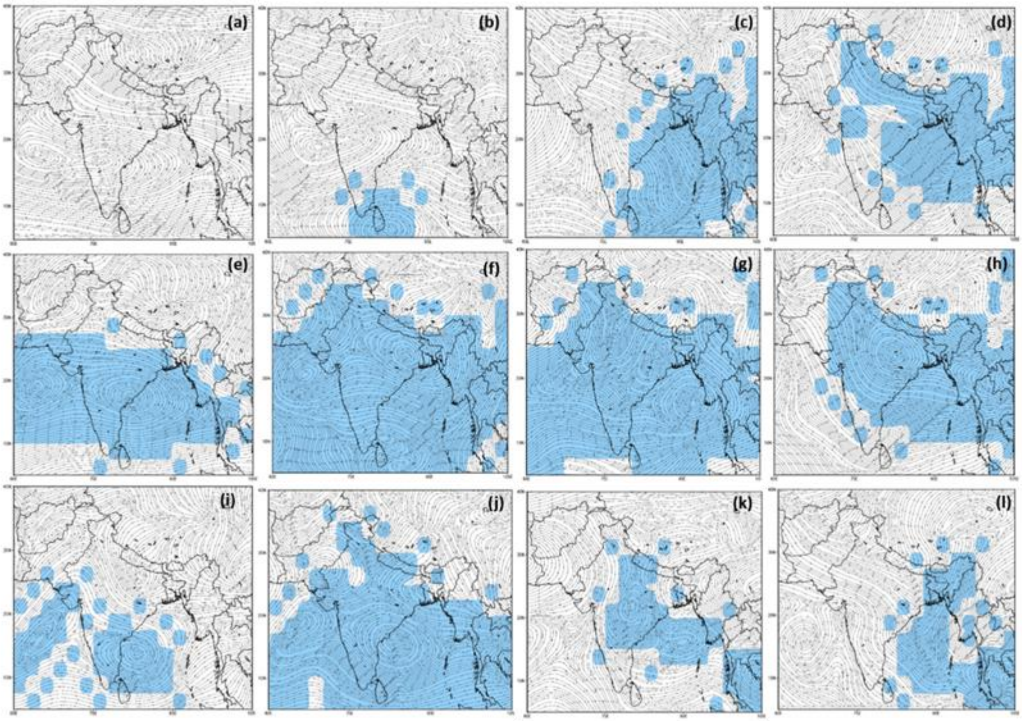


Fig.1 Area under monsoon condition; aqua blue shaded), and 600-hPa streamlines across Indian subcontinent from a) 30 April through l) 15 October at fortnight interval normally.

It has been seen that, normally the effective Indian monsoon condition starts earliest on 31 May over South-east India and latest on 19 June over Northwest region region and finishes first on 9 Sept from extreme northern region and latest on 26 Sept from East Coast. While, effective monsoon rains start normally 2 days after the start of effective Indian monsoon condition and finish 4 days before it (fig.2).

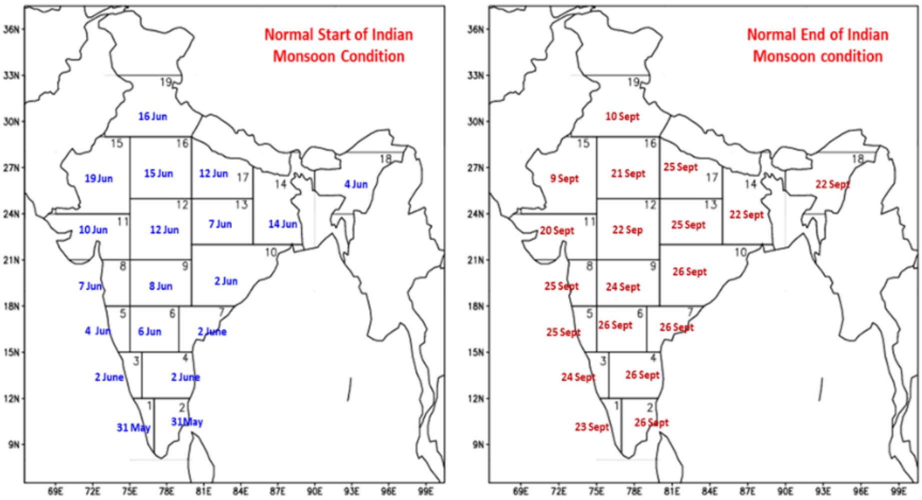


Fig 2. Normal start and end dates of Indian monsoon condition

2. Meteorological conditions associated with 23-28 July 2005 most extreme rain event over Peninsular India

Most heavy rains over India during 1951-2007 occurred from 23-28 July 2005. Each day the country received 20.2 billion cubic meters (bcm) rainwater. The highest rainwater was collected on 25th July (98.2 bcm) over 45.9% area of the India. In the study, investigation has been carried to understand departure from normal in global atmospheric thermal condition, and 3D structure of monsoon and general atmospheric circulations during the heaviest wetspell (23-28 July 2005). Atmospheric condition has been described with respect to equatorial mean as reference. It has been seen that, the monsoon evolves in association with spreading and intensification of equatorial atmospheric condition over Afroeurasian landmass and adjoining Indian and Pacific Oceans during boreal summer. Robust natural criteria have been applied to demarcate monsoon and other global weather regimes (GWRs) at standard levels (1000−100-hPa). Global atmospheric (1000−100-hPa) thermal condition and monsoon and general circulations during 23-28 July 2005 have been compared with normal features of respective parameters.

Over tropics-subtropics (45°S-45°N), the troposphere (1000−250-hPa) was warmer-thicker and pressure lower than normal and mixed conditions of positive/negative departures in temperature, height/thickness and pressure was observed over northern and southern mid-high latitudes. Noticeable changes in 3D monsoon structure were listed as: i) horizontally spread and eastward-southward shifted over western North Pacific and stretched further southeastward across equatorial Pacific; ii) intense warm-low lower tropospheric confluence-convergence across Asia-Pacific with vertical depth extending beyond 400-hPa; and iii) intense warm-high upper tropospheric anticyclonic circulation zonally stretched and divided into three interconnected cells as shown in Fig 3. Outflows from anticyclonic cells over Tibetan plateau and western North Pacific were mostly directed westward/southwestward/southward. Troposphere was warmer-thicker and pressure higher over eastern part of both subpolars-polars and cooler-thinner and pressure lower over western part. During the period, a deep cyclonic circulation moved from Bay of Bengal through central India while near-stationary atmospheric condition prevailed across the globe.

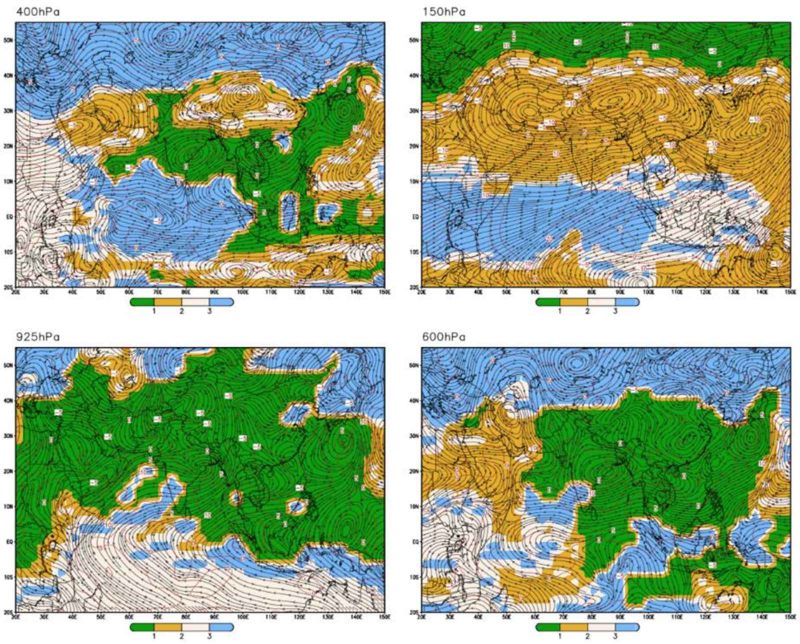


Fig.3 Actual GWR, streamline and GC-W at 925-hPa, 600-hPa, 400-hPa and 150-hPa on 25 July 2005 for over extended Asia-Pacific region

3. Possible Mechanism of Disastrous Rains over Kedarnath Range (western Himalaya, India) during 16-17 June 2013

During 16-17 June 2013, the state Uttarakhand and nearby states experienced very heavy above normal (375%) rainfall caused devasting floods and landslides. The idea of the present study is to understand the underlying mechanism that causes severe rainstorm along southern slopes of Himalayas using equatorially/globally conditioned meteorological analysis of meteorological parameters and monsoon circulation. Perhaps most unusual atmospheric thermal structure developed during 1-20 June 2013 (peaked on 16-17 2013) with warmer-thicker (than equator) troposphere over Tibet-China sector and another over Middle East – Mediterranean sector, and cooler-thinner over central Asia – Afghanistan – Pakistan – northwestern India. A deep subtropical high evolved over Middle East – Mediterranean sector and lower tropospheric convergence and upper tropospheric divergence over Tibet – China, while a deep trough over central Asia – Afghanistan - Pakistan – northwestern India. Three flows got merged over western slopes of the Tibet – Himalaya sector during 16-17 June 2013; i) eastern side of the cool-dry deep trough over central Asia – India sector; ii) rising warm-moist airs from convergences across Arabian Sea – India - Bay of Bengal of Bengal – Indochina – South China Sea – Philippines Sea; and rotating warm-dry airs of the anticyclonic cell over Tibet – China. Squeezing of the combined three flows and their lifting due to orography and pumping-suction effects produced unprecedented rains over Kedarnath range (western slope of Tibet – Himalaya). After short spurt of confluencing, converging and condensing, the central Asia – India trough weakened and moved eastward over Tibetan plateau which destroyed warm-high Tibet – China anticyclonic cell and rainfall activities virtually subsided. Formation and intensification of troughs in the temperate westerlies is a short period phenomenon. Therefore, condensation and intense rainfall in subtropical mountainous terrain involving confluence and convergence of huge airmasses of contrasting characteristics are short lived. The phenomenon is popularly known as ‘cloud burst’.

Meteorological causes of the disastrous rains of June 16-17, 2013 over Kedarnath range has been investigated by comparing actual with normal global 3-D structure of following atmospheric parameters: equatorially-conditioned pressure, precipitable water, and levelwise (1000-100-hPa) temperature and geopotential height, unconditioned streamlines and globally-conditioned horizontal windspeed. Normally during this time, warmest-thickest troposphere occurs over subtropical Afroeurasia, and lower tropospheric flows are directed northeastward over Indian subcontinent. In lower levels (1000-850-hPa), cross-equatorial flows over Indian Ocean cover Arabian Sea, Indian peninsula, Bay of Bengal and South China Sea, blow over eastern Tibet-China, and then northern North Pacific. In middle levels (700-500-hPa), north temperate westerlies enter into Indian domain through Afghanistan-Pakistan, evolved into garland-like trough around Tibet-Himalaya, and make exit toward northeast Tibet-China and further northern North Pacific. An elliptical anticyclonic circulation occurs over subtropical Afroasia in the layer 300-100-hPa with major axis along 25°N latitude. During 15-18 June 2013 (peaked on 16-17 June), there was development of peculiar atmospheric thermal structure over Afroeurasian landmass with warmer-thicker (than normal) troposphere over Tibet-China and over Afroeurasia - Middle East, and cooler-thinner over central Asia-India. During 16-17 June 2013, lower tropospheric flows were directed northwestward. There was confluence of three huge airflows of contrasting characteristics over western slopes of Tibet-Himalayan massif: eastern side of cool-low-dry central Asia-India trough, warm-low-moist airs rising from convergences across Arabian Sea - Philippine Sea, and warm-high rotating airflows of Tibet-China anticyclone. Enhanced convergence and condensation due to orographic and pumping-suction effects produced unprecedented rains over Kedarnath range.

Study benefits and Adopters of the results of the study:

The results from this study are helpful in order to develop operational forecasting scheme for the determination and prediction of yearwise onset and withdrawal of summer monsoon across India. This study can provide useful information to make an estimate of likely duration of rainfall activities across different river basins in India. Scientifically, it can also give information about the cause and occurrences of extreme hydro-meteorological disasters.

Major items of equipment procured:

i) Workstation; ii) Printer; iii) UPS

Lab facilities during the study: None

Data generated in the study:

Climatological and Yearwise start and end dates of summer monsoon over 19 subdivisions of India during 1979-2015.

Specific linkages with Institutions/beneficiaries: None

Shortcomings/Difficulties: Shortage of high resolution observed data of meteorological parameters in order to validate the results

Future Plan: Impact of climate change on general circulation features and extreme rain events across India

2. Hydrological modeling in Alaknanda basin and assessment of climate change impact

PROJECT REFERENCE CODE: NIH/SWHD/16-21

1.	Title of the project	**Hydrological modelling in Alaknanda basin and assessment of climate change impact**
2.	DST reference No	SP-06
3.	PI's name, Address, Contact No.	Dr. A.K. Lohani, Scientist-G, SWHD, NIH Roorkee
4.	Total cost of the project	42.296 (Rs. in Lakh)
5.	Duration	Jan '16 – Dec' 20 (5 years)
6.	Date of Start of the project	January, 2016
7.	Date of Completion	December, 2020
8.	Period of Report	From Jan, 16 To Mar, 17
9.	Funds Received	
	a. Sanction Number	DST/SPLICE/CCP/NMSHE/TF-4/NIH/2015-G
	b. Date of sanction:	13/01/2016

Brief of work carried out so far

The Alaknanda river is a major Himalayan glacial stream. The river traverses 229 km before its confluence with Bhagirathi at Devprayag to constitute the Ganga, the major and holiest river of India. The Alaknanda originates at a height of 3641 meters below Balakun peak 16 km upstream of Badrinath from the two glaciers of Bhagirath Kharak and Satopanth. In order to carry out hydrological modelling in the Alaknanda river basin status of the available data and information have been collected further a detailed review of the snowmelt runoff modelling methodology have been carried out. Spatial data of the study basin have been collected. Various maps such as basin map (Fig 1), drainage map, landuse map, DEM (Fig. 2), snow cover area maps of the basin have been prepared. Furthermore, grided rainfall data of the study basin have been collected and processed. Snowmelt runoff model is being setup for the study basin. Flow data is required for the calibration and validation of the model. Available G& D data in the basin has been identified and efforts are being made to collect these data.

1. **Approved Objectives of the Project:**

- To model stream flow/snow melt runoff in Alaknanda Basin.
- To investigate the impact of likely future changes in climate on stream flow in the study area using future climate scenarios.
- To estimate seasonally varying Temperature Lapse Rate (TLR) using LST data estimated from thermal satellite image in Alaknanda basin.

2. **Physical Progress**

- Basin map, drainage map, landuse map, DEM, snow cover area maps of the basin have been prepared (Fig. 1).
- Processed gridded rainfall data of the study basin.
- Snow cover area map of the basin have been prepare.
- Snowmelt runoff model has been setup for the study basin.
- Flow data obtained from CWC has been processed
- Model setup has been carried out with prepared spatial data and gridded rainfall data.
- Model calibration is in progress.

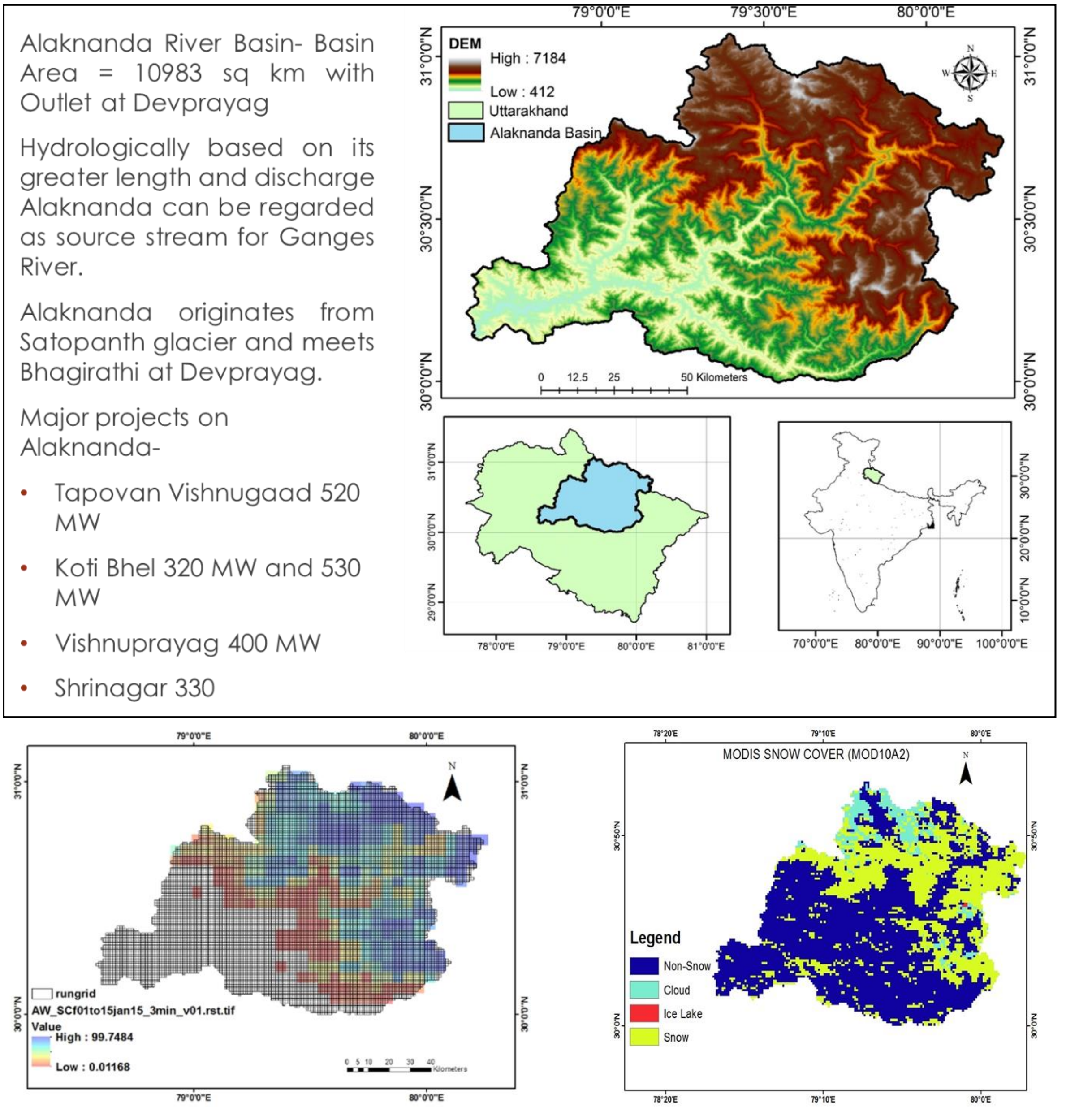


Figure-1

3. Work Plan and Expected deliverables

Activity	1st year		2nd year		3rd year		4th year		5th year	
	I	II	I	II	I	II	I	II	I	II
Collection of hydrological and hydro-meteorological data from various agencies and entry in SWDES software	◄	—	—	—	—	—	—	►		
Generation/import of spatial data layers for the study area and reference database from different sources	◄	—	—	►						
Processing and analysis of data in SWDES and HYMOS software			◄	—	—	►				
Evaluation of various components of hydrologic cycle in different spatial and temporal scales, trend and correlation analysis					◄	—	—	—	►	

Analysis and design of observation network										
Development of project web site including linkage with web-based hydrological information system										
Capacity building										

3. Water Efficient Irrigation by using SCADA system for medium Irrigation Project (MIP) Shahnehar

PROJECT REFERENCE CODE: NIH/SWHD/17-20

Title of the study : **WATER EFFICIENT IRRIGATION BY USING SCADA SYSTEM FOR MEDIUM IRRIGATION PROJECT (MIP) SHAHNEHAR**

Project team
Name of PI: **Dr. R.P. Pandey, Scientist G**.
Name of Co-PI: **Sh. J.P. Patra, Scientist C**
Dr. Rajesh Singh, Scientist C,
Sh N. K. Bhatnagar, Scientist B

Type of study: PDS (NHP)

Collaborating Institutions

Department of Irrigation & Public Health Engg. (I&PHE), Hydrology C&M Division, Tutikandi, Shimla-4. Himachal Pradesh	**National Institute of Hydrology Roorkee -247667**

Total Project Cost: Rs.75.0 lakh (**Funded by NHP)**
NIH Cost Allocation Rs. 15.0 lakh

Project Duration: **3-years**

Date of start: **December, 2017**

Scheduled Date of Completion: **December, 2020**

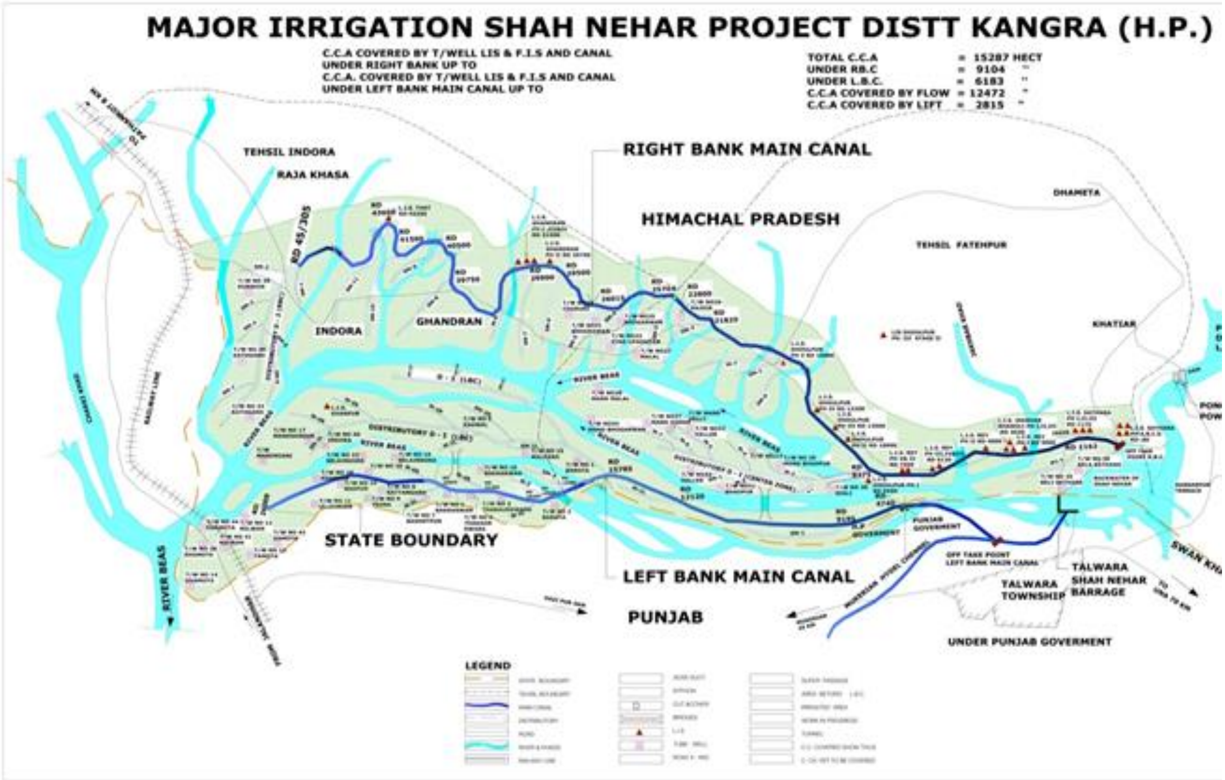
OBJECTIVES OF THE STUDY:

The primary objective of this study is to **Devise a suitable approach to improve irrigation water use efficiency in Shah Nehar Project.** The specific objectives of the study are as follows:

- To develop monitoring, supervisory control and modernize system for Agriculture Irrigation water.
- Paradigm shift in the approach from a supply-based system to a demand-based sustainable system.
- Real time monitoring of water availability at head works.
- Performance evaluation of Left Bank Canal and Right Bank Canal of MIP Shah Nehar Project.
- Identify issues that need to be addressed to improve project performance
- Suggest measures to improve water use efficiency & sustainability up to farm level.
- Integrating Warabandi with SCADA system.

Study Area : Shah Nehar Command Area, Himachal Pradesh

Shah Nehar Irrigation Project in District Kangra, Himachal Pradesh is first Major Irrigation Project of the state amounting to Rs.143.32 crore was approved by the HP Govt to irrigate 15287 hectares of land of 93 villages situated on right and left bank of river Beas by constructing two numbers of main canals on each bank with a length of 45.30 and 25.69 km respectively. The water was fetched from outfall of Pong Dam by signing agreement between Govt. of HP and Punjab Govt. on 4/8/1983.The index map of Shah Nehar project command area is given in Figure below.



Whole of the Right bank canal enroots through the jurisdiction of Himachal Pradesh whereas about 4.0 Km of LBC out of 25.69 km falls in the state of Punjab. Out of total cost of Rs 143.32 crore the Govt. of Punjab was to share Rs 88.49 crore and remaining Rs 54.83 crore was to be borne by the Govt. of H.P. Later on due to price escalation revised DPR was prepared and approved to the tune Rs 387.17 crores at price level 2010 in 110th meeting of advisory committee of CWC. The project was included under Accelerated Irrigation Benefit Program (**AIBP**) with 90% Central Aid and balance 10% had to be shared by Govt. of Punjab and HP in the ratio of 61.74% and 38.26%.

Description of the Problem

At present the Shah Nehar project experiences improper distribution of water into the agricultural fields resulting into low yield of crops and therefore necessity of water efficient irrigation system by using SCADA. The primary objectives of the proposed study are to enhance water use efficiency, minimize water losses and to increase productivity in the command area of Shah Nehar project. The Shah Nehar project is first major Irrigation project in Himanchal Pradesh. Presently, water is being supplied to 93 villages comprise of 15287 hectares Culturable Command Area (CCA) through several outlets provided in the main canal. From each outlet the water is transported by gravity or lift scheme to each chak proposed in the command area development. The water demand of each outlet is based on the cropping pattern proposed in the respective chak. The roster of water demand is based on the warabandi schedule prepared by the Irrigation & Public Health Department in consultation with Krishi Vikas Sangh/Water User Associations.

It is proposed to quantify available water at the head-works of the canal system during cropping period, estimation of irrigation water requirement for existing cropping pattern, assessment of losses at the conveyance, distribution and application of water in the command area. The study will be helpful in identification of the potential area which requires appropriate land and water management intervention for improvement of water use efficiency. Further the study will be useful in quantifying the potential of improvement in irrigation water use efficiency in the Shah Nehar command area.

The HP IPH Department has listed the problems of irrigation water management in the Shah Neha Project based on input received from the farmers, observations made during their field visits and consultation with specialized agronomists as follows:

- ✓ Non availability of water during peak demand of crops at the tail end of command area.
- ✓ No check over theft of water from the main canals.
- ✓ Irrigation systems play vital role for sustainable agricultural development in Himachal Pradesh, but major problem of which is rather low efficiency of water use.
- ✓ No accountability due to absence of water accounting & audits.
- ✓ Poor and low consistency management of the irrigation systems efficiency.
- ✓ Lack of reliable monitoring network and supervisory control for irrigation systems.
- ✓ Non availability of effective decision making tool to improve irrigation management.
- ✓ Huge water loss due to random irrigation process.
- ✓ Lack of awareness about modern and water efficient irrigation methods.

Proposed Methodology

The purpose of the proposed study is to examine the present status of the Shah Nehar Irrigation Project water use efficiency, quantify the water losses in the main canal system & distributaries, water courses and field application. Determination of time based crop water demand and supply for existing cropping pattern and identification of irrigation system components needing water management interventions to improve water use efficiency of system and maximize the benefit from the Shah Nehar project. The work component will include the following:

1. Monitoring of supply and distribution of water in conveyance, distributary outlets and the on form irrigation application at selected experimental sites.
2. Assessment of the real time availability of water at head works, at various outlets in the main canal and tail ends of distribution system during the Rabi, Kharif and Zaid crop period.
3. Assessment of site specific water requirement for suitable time-steps during cropping periods in different seasons
4. Devising a methodology regarding equitable distribution of water to the farmers in each crop period from head to tail reaches by using SCADA.
5. Develop a system of water supply database of quantum of water used to each beneficiary so the charges can be levied accordingly.
6. Devising a possible system of change in cropping pattern owing to real time monitoring of available water at various reaches of the canal.
7. Identification and evaluation of intervention to minimize water losses throughout the canal and distribution system, water courses and in the field application to enhance the water use efficiency.
8.

From the data collection and analysis of the data, Water efficient Irrigation by using SCADA System will be provided so that water can be used more efficiently and hence it will increase the effectiveness of the Irrigation Project.

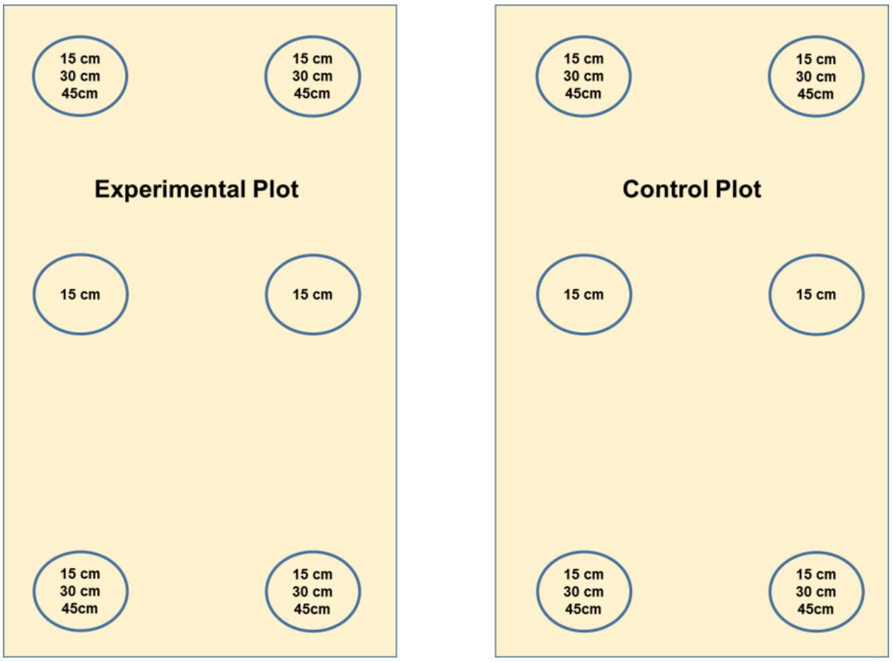
Progress of Work

The team NIH Scientist visited study area and conducted detailed survey of Shahnehar Project Command Area, along with Himachal Pradesh I &PHE department officials. Detailed plan for the selected experiment sites was prepared after discussion with I&PHE officials. after field survey to finalize the project modalities and work plan for the study. The pilot sites for detailed experimentation have been identified. Field investigation and instrumentation for field experimentation for the study has been finalization after meeting with the project team of the lead organization (I&PHE, Shimla) to setup monitoring schedule.

The irrigation command site for SCADA implementation has been finalized.

1. The meteorological data for the assessment of present irrigation requirement has been collected from BBMB meteorological station at pong dam site.
2. The estimation of Pet and the crop water requirement for the study has been worked out.
3. The Himachal Pradesh I &PHE department has been further requested to obtain data from Kangra Agriculture College/other stations in the vicinity of the project site.
4. Base maps for the study sites have been prepared.

5. The experimental sited identified are as follows:
   i. Lift Irrigation Scheme (LIS) Sthana, Terrac Sub-Division—for SCADA experimentation.
   ii. Selected sites/field plots in distributary-1 (D-1) command area –Badukhar Sub-Division --for experimentation-1 in middle reaches.
   iii. Selected sites/field plots in distributary-2 (D-2) command area- for experimentation-2 in tail reaches.
6. Field investigations have been carried out and the layout of the experimental plots for installation of moisture sensors for measurement of crop root-zone moisture at the three sites have been prepared as follows.



S.N. (1)	Instrument/ Sensor (2)	At one Site (3)	For Three Site (4)=(3)*3
1	Moisture and temperature sensor • at 15, 30, 45 cm depth • at 15 cm depth	 8 4	 24 12
2	Flow meter (Discharge measurement)	3	9
3	Data logger/transmitter	1*	3*

7. Department of I & PHE, Shimla, Govt. of Himachal is processing procurement of discharge & Moisture measurement sensor and installation in the field. The procurement is under process at present.

Further Proposed Work Plan for next year

- Installation of sensors and telemetry system for soil moisture monitoring and data transmission.
- Application of field irrigation under measured and controlled conditions. (replication at three sites).
- Quantification of irrigation water loss in different conveyance & distribution systems, field channels, and irrigation application methods.
- To evolve irrigation scheduling (revision) considering the crops, soil moisture and prevailing climatic conditions.

- Demonstrations and conducting workshops on OFWM practices for all the stakeholders including farmers.
- To review the role of existing Water Use Associations (WUA) and suggest suitable
- To extend the improved/scientific modifications for encouraging the better OFWM practices and equitable water distribution among the farmers.
- Review of the existing Cropping patterns during different sowing seasons and suggest suitable crops for each season to enable optimum utilization of available water.

Deliverable:

1. Estimates of water availability at headwork's and irrigation water requirements for various crops a different growth stages & time period.
2. Quantification of irrigation water loss in different conveyance & distribution systems, field channels, and irrigation application methods.
3. Identification of components of irrigation system needing intervention to enhance water use efficiency.
4. Experimental assessment of SCADA based approach in the enhancement of water use efficiency.

4. Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin (3f)

PROJECT REFERENCE CODE: NIH/SWHD/17-21

1. **Title of Study:** Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin (3f)

2. **Study Group:** - Sanjay Kumar, Sc-E, PI
Rakesh Kumar Sc-G
J. P. Patra Sc 'C'
Pankaj Mani, Sc 'E'

3. **Location Map:**

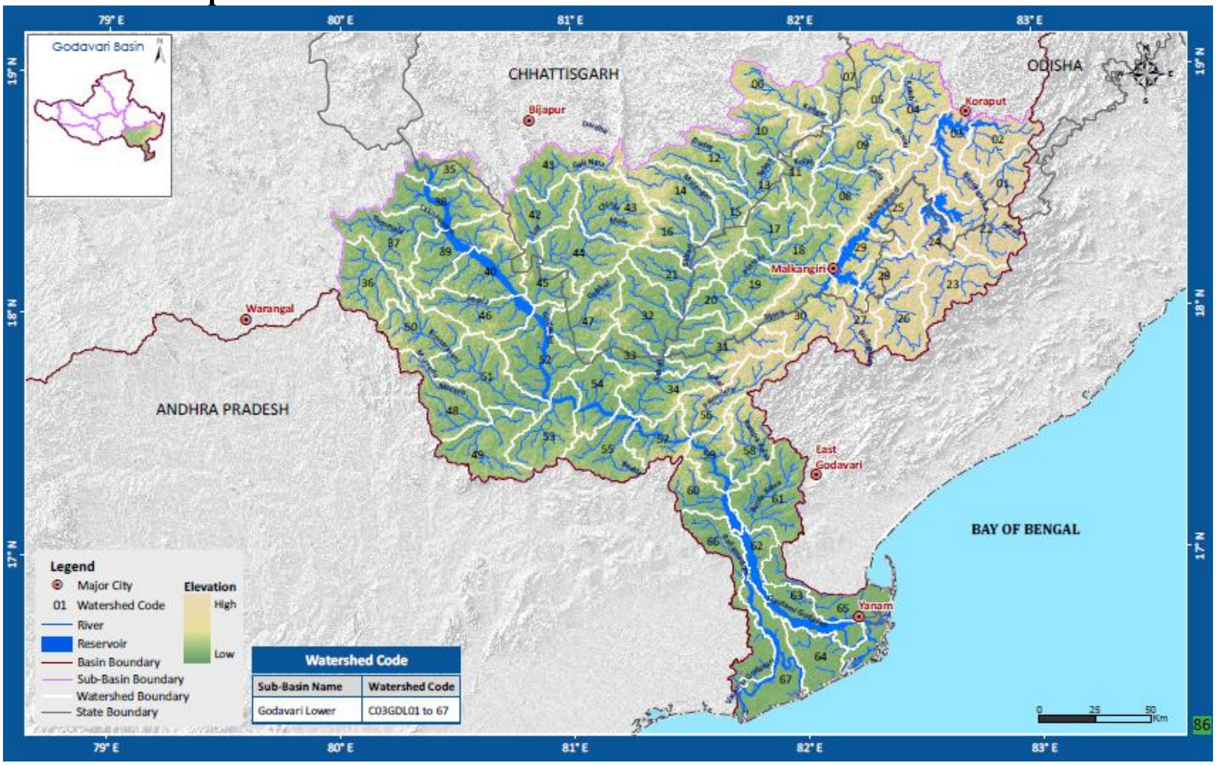


Fig 1: Location Map of the study Area

4. **Objectives of the study:**

The objectives of the study are:

(i) To develop regional relationships for (surface) water availability analysis.
(ii) Development of at site and regional flood frequency analysis using L Moments.
(iii) Development of at site and regional rainfall frequency analysis using L moments.
(iv) Development of regional relationships for Nash and Clark IUH models parameters.
(v) Impact of climate change on flood estimates.

5. **Statement of the problem:**

The surface water availability analysis is the foremost task for planning any project on a river. Accurate estimation of the total quantity of surface water availability and its variation is important for the success of any project. Depending on the type of data availability different methods and regional relationships would be used/ developed for water availability computations.

The study would also estimate design flood for various return periods needed for different types of water resources structures. These structures are often planned in regions with less or no hydro-metrological information/data. Studies carried out for such conditions are limited and based on various types of conventional techniques. This study specifically focuses on developing design flood estimation methods for such partially gauged or un-gauged regions based on the concept of regionalization. In regions where only rainfall data is available, the study would carry out at-site and regional rainfall frequency analysis using L-moments. The study would also develop relationship between mean annual peak floods and physiographic characteristics of the basin and develop regional relationships for NASH and Clark IUH model parameters. These developed relationships would finally used for estimation of floods of various return periods. The impact of climate change on flood estimates would also be evaluated.

6. Methodology:

For estimation of T-year return period flood at a site, the estimate for mean annual peak flood is required. For gauged catchments, such estimates can be obtained based on the at-site mean of the annual maximum peak flood data. At-site and regional flood frequency analysis will be performed using the L-Moments approach, which includes various frequency distributions: viz. Extreme value (EV1), Generalized extreme value (GEV), Logistic (LOS), Generalized logistic (GLO), Normal (NOR), Generalized normal (GNO), Uniform (UNF), Pearson Type-III (PE3), Exponential (EXP), Generalized Pareto (GPA), Kappa (KAP), and five parameter Wakeby (WAK). Screening of the data, testing of regional homogeneity and identification of distribution will be carried out.
However, for ungauged catchments at-site mean cannot be computed in absence of the flow data and in such a situation, a regional relationship between the mean annual peak flood of gauged catchments in the region and their pertinent physiographic and climatic characteristics is needed for estimation of the mean annual peak flood. For example, the form of this regional relationship may be:

$$\overline{Q} = a\, A^{b} S^{c} D^{d} R^{e}$$

Here, ($\overline{Q}$) is the mean annual peak flood, A is the catchment area, S is the slope, D is the drainage density, R is the annual normal rainfall or rainfall for the duration of annual maximum peak flood for the catchment etc., a, b, c, d, and e are the regional coefficients. Further, relationship of various other characteristics like length of main stream (L), centroidal longest flow path (L_c) etc. with peak flood will also be evaluated. The regional coefficients will be estimated using the mean annual peak floods of the gauged catchments and their pertinent physiographic and climatic characteristics for a region. The physiographic and climatic characteristics which are considered pertinent for generation of annual maximum peak floods from a catchment and can be obtained from the observed records e.g. rainfall for the duration of occurrence of the annual maximum peak floods and derived from the toposheets/maps of the gauged catchments may be considered for development of this relationship. Downscaled climate change projections would also be used for evaluation of impact on flood estimates.

6 Deliverables

- Regional relationships for water availability analysis,
- Flood estimates for various return periods for gauged catchments.
- Regional Relationship between mean peak floods of various return periods with catchment characteristics.
- Regional Relationships for estimation of floods of various return periods for un-gauged catchments.
- Regional relationships for Nash and Clark IUH model parameters.
- Impact of climate change on flood estimates.
- Research papers and Report

7 Progress

L moments for annual maximum series at different sites have been estimated for at-site frequency analysis. NAM calibration and validation for some gauged basins and its application in un-gauged basin is under progress. CWC is requested to provide hydro-metrological data available with them for the lower Godavari basin. Secondary data from other sources such as Flood Estimation Reports, PMP atlases and similar studies in basin, is also being collected.

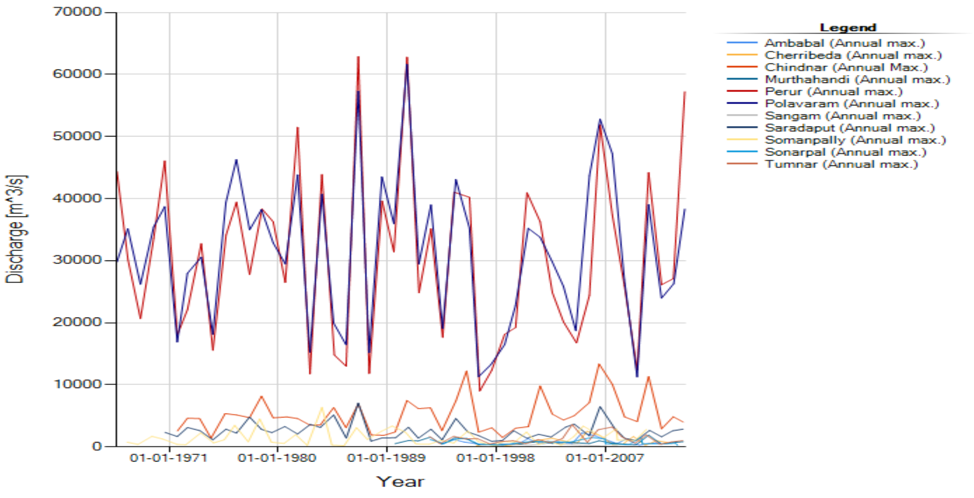


Fig 2: Observed Annual Maximum Flood Series

Table1: L moments of Annual Maximum Series at Various Gauging Sites

Site Name	**L Moments**			
	L_1	**L_2**	**L_skewness**	**L_Kurtosis**
Ambabal (Annual max.)	803.76	265.09	0.41	0.25
Cherribeda (Annual max.)	847.71	369.69	0.27	0.13
Chindnar (Annual Max.)	5,169.20	1,540.46	0.24	0.18
Murthahandi (Annual max.)	749.77	225.99	0.31	0.15
Perur (Annual max.)	30,675.35	7,939.15	0.1	0.07
Polavaram (Annual max.)	31,506.85	6,890.04	0.03	0.09
Sangam (Annual max.)	320.89	106.93	0.41	0.38
Saradaput (Annual max.)	2,550.70	736.86	0.25	0.18
Somanpally (Annual max.)	1,503.15	697.17	0.32	0.12
Sonarpal (Annual max.)	767.4	236.84	0.18	0.03
Tumnar (Annual max.)	1,318.56	471.3	0.32	0.17

5. Study of hydrological changes in selected watersheds in view of climate change in India

PROJECT REFERENCE CODE: NIH/SWHD/15-19

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

2. **Project team:**

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

3. Objectives-

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

4. Present state-of-art

The climate of earth has never been stable for any extended period but varying naturally on all time scales. Climate change has greatly affected the characteristics of climatic variables globally. These changes are not uniform but vary from place to place or region to region. Probable climate change and its perilous impacts on the hydrologic system pose a threat to global fresh water resources and aquatic ecosystems worldwide.

The present study is envisaged in this context to take up the study on the assessment of hydrological changes in different watersheds in India under changing environment.

5. Methodology-

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

6. Research outcome from the project

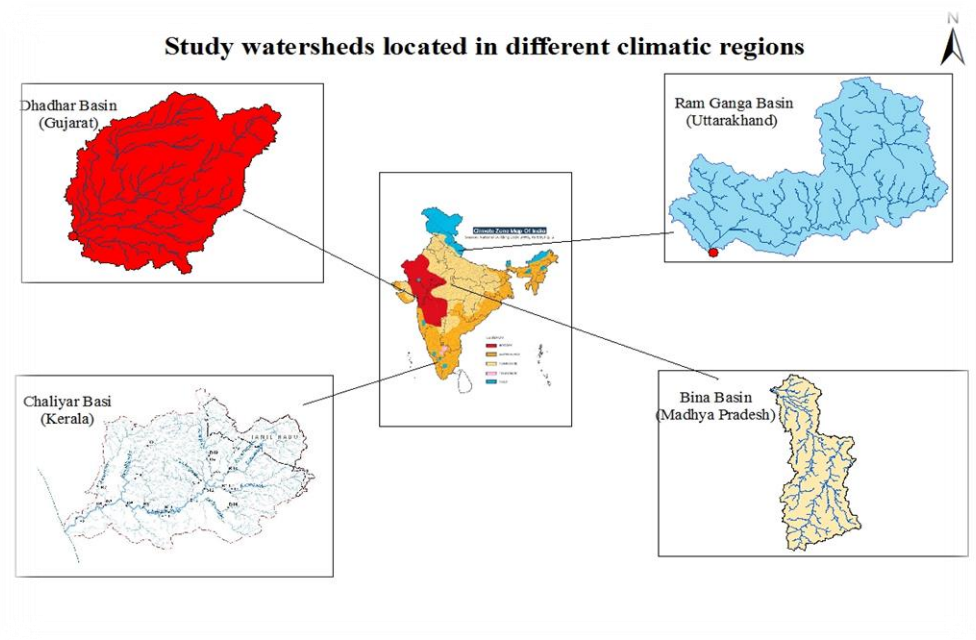
The outcome of the study will help in assessment of water resources availability and impact of climate change at basin scale.

7. Progress of Work

Four different watersheds located in different climatic regions namely Dhadhar river basin (Gujarat), Ramganga up to Kalagarh (Uttarakhand), Bina River basin (M.P) and Chaliyar river basin (Kerala) as shown in Figure 1. have been selected for the present study. The hydro-meteorological data pertaining to the four river basins namely Ramganga, Bina, Chaliyar and Dhadhar have been processed to meet out different objectives of the study. The various inputs for the hydrological model such as Digital Elevation Model (Dem), landuse/lander, covsoil map etc. have been prepared.

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

Digital elevation models (DEMs) are grid-based GIS coverages that represent elevation. Downloaded DEM was processed for removal of sinks, thereafter the filled DEM has been used to generate the flow direction, flow accumulation maps in the GIS environment for the delineation of drainage networks and watershed boundaries for the four watersheds. Moreover, land use/land cover, soil map etc. thematic maps esstential for the modeling have also been prepared for the study areas. Statistical methods for spatio-temporal temporal analysis of meteorological data using parametric and non-parametric approach have been applied to determine the trends in the rainfall time series. Moreover, spatial variation of ground water levels along with drought characterization for the river basins have been carried out. The hydrological models (NAM and SWAT) have been setup for the river basins. Input databse namely Landuse/landcover, DEM, Soil/Satellite data for the Dhadhar basin has been completed. The hydrological model have been calibrated and validated for the Dhadhar river basin. Grided data of rainfall and temperature of IMD of four watresheds have been prepared for downscaling using SDSM. Moreover, downloaded Canadian Earth System Model (CanESM2) scenarios for the study area.



8.Progress since last working group

Statistical downscaling of meteorological data namely daily rainfall, minimum, maximum and average temperature for the Dhadhar, Bina and Chaliyar basin using statistical downscaling model (SDSM). SDSM is based on multiple linear regression (MLR) technique. The model has been calibrated and validated based on rainfall and temperature of period 1961-1995 and 1996-2005 respectively with large-scale predictors of National centre for Environmental Prediction (NCEP) reanalysis data. It is proposed to grant extension up to March 2020 for the study.

6. Development of regional methods for design flood estimation in Uttarakhand.

PROJECT REFERENCE CODE: NIH/SWHD/17-20

1. Title of the study: Development of regional methods for design flood estimation in Uttarakhand.

2. Study group: J. P. Patra, Sc. 'C'; Rakesh Kumar, Sc. 'G' & Head, Pankaj Mani, Sc. 'E', CFMS, Patna; Sanjay Kumar, Sc 'E'
Technical assistance: T. R. Sapra, RA.

3. Duration of study: 3 Years (April 2017 to March 2020) : Ongoing

4. Type of study: Internal.

5. Location map

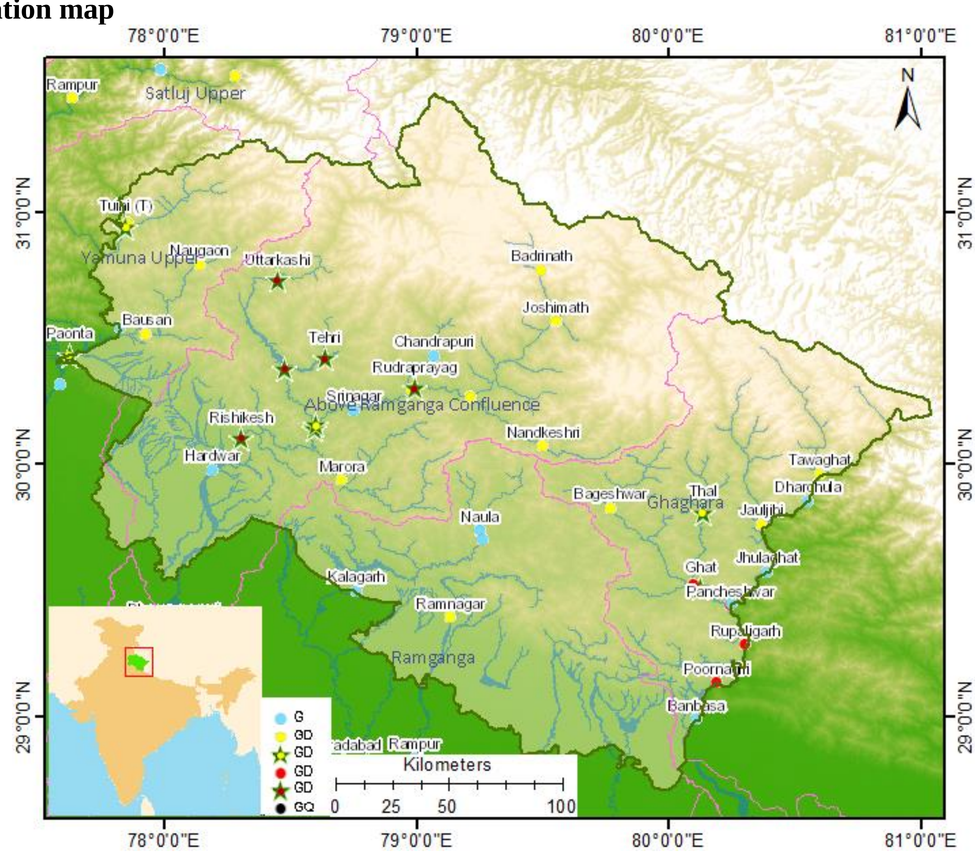


Fig. 1: Location map of study area.

6. Study objectives:

a) Development of at-site flood frequency relationships using L-moments.
b) Development of at-site and regional flood frequency relationships using L-moments.
c) Development of regional relationships between mean annual peak floods and physiographic and climatic characteristics.
d) Development of at-site rainfall frequency relationships using L-moments using point rainfall data.
e) Development of at-site and regional rainfall frequency relationships using L-moments using gridded rainfall data of various sources.
f) Development of regional relationships for the Nash and Clark IUH model parameters.
g) Estimation of floods of various return periods for Ganga basin in Uttarakhand.
h) Development of flood frequency relationships under climate change scenarios.

7. Statement of the problem

The commonly used design floods estimation approaches can be categorized as: flood formulae, flood frequency analysis and hydrometeorological approach (CWC, 2010). Various empirical flood formulae have been developed for regions. These include Dicken's, Ryve's, Nawab Jung Bahadur, W P Creager's, Jarvis f, Modified Myer's etc. When long term and short term rainfall and runoff records are not available the design flood is obtained using these formulae. However, the value obtained from these can only be used for preliminary estimates for small catchments and the concept of return period flood is generally not included in this approach. The flood frequency approach can be adopted in case data of peak floods series are available for a longer period of time. In, Indian generally Gumbel or Generalized Extreme Value (GEV) distributions are fitted to the peak flood series without considering other available frequency distributions. Flood estimation reports for various sub zones have been prepared with joint efforts of Central Water Commission (CWC), India Meteorological Department (IMD) and Research Design and Standards Organisation (RDSO) of Ministry of Railways and Ministry of Surface Transport (MOST) for estimating design floods of 25, 50 and 100 year return periods for design of waterways, bridge, culverts etc having small and medium catchments where hydrological data are inadequate or totally absent. Recently, PMP atlas for various basins of India has been developed by CWC and IMD for assessment of design storm as required in the assessment of design flood for any water resources development project. The point rainfall at various raingauge stations are analysed and rainfall of various return periods have been estimated by fitting a two parameter Gumbel frequency distribution. Various new techniques of flood frequency analysis are being developed by various researchers for selecting candidate frequency distribution, parameter estimation etc. (L-Moments, PWM etc.). There is a need to use better parameter estimation technique for estimation of parameter of candidate distribution.

In India for many catchments, streamflow data are not available or the data are inadequate at the site of interest. In such cases the methods of frequency analysis using data from a single site have limited applicability because of large sampling errors, and as a result, regional flood frequency analysis is performed. The various commonly used methods of regional flood frequency analysis are: USGS method, Pooled curve method, analytical method and L-moments approach. Hosking and Wallis (1997) presented the L-Moments based regional frequency analysis approach. The authors mention that regional flood frequency analysis resolves the problem of short data records or unavailability of data by "trading space for time"; as the data from several sites are used in estimating flood frequencies at any site. Kumar et al. (2003, 2005, 2015) applied L-moments approach for development of regional flood frequency relationships for some of the regions of India. Komi et al. (2006) carried out regional frequency analysis based on L-moments and identified three homogeneous based on cluster analysis and a homogeneity test. Finally, regression models of the mean annual flood with the size of the drainage area, mean basin slope and mean annual rainfall are proposed to enable flood frequency estimation of ungauged sites within the basin. Design flood estimates in the United Kingdom are routinely obtained by using the improved Flood Estimation Handbook (FEH) statistical procedure (Kjeldsen, 2015). The author assessed uncertainty of design flood estimates at ungauged catchments for a range of return periods. The results show that the inclusion of data from nearby gauged catchments increases the reliability of the estimates when compared to an automated application of the improved FEH methods relying on catchment descriptors only. Analysis of 190 storm events in seventeen small Northern Ireland catchments, along lines developed by the UK Institute of Hydrology, shows that the time-to-peak of the instantaneous unit hydrograph can be estimated from catchment characteristics and from the time between the centroid of mass of a flood-producing rainfall event and of the resulting peak flow, but that equations calibrated on British data overestimate the time-to-peak (Gardner and Wilcock, 2003). This might be due to the distinctive hydrology of Northern Ireland. Kumar et al. (2007) developed geomorphological instantaneous unit hydrograph (GIUH) based Clark and Nash models and applied for simulation of the direct surface run-off (DSRO) hydrographs for ten rainfall-runoff events of the Ajay catchment up to the Sarath gauging site of eastern India. The GIUH is derived from the geomorphological characteristics of a catchment and it is related to the parameters of the Clark instantaneous unit hydrograph (IUH) model as well as the Nash IUH model for deriving its complete shape. Inter comparison of the performances of the GIUH based Clark and Nash models shows that the DSRO hydrographs are estimated with comparable accuracy by both the models.

Over the year, efforts have been made toward regionalisation of catchment model parameters of various complexity and scale (Seibert, 2009; Merz and Blöschl, 2004; Littlewood, 2004; Heuvelmans et al., 2006; Bastola et al., 2008; Bárdossy and Singh, 2011; Beck et al, 2016). A comparison of regionalisation methods for catchment model parameters is provided by Parajka et al., (2005). Hydrologic model parameters obtained from regional regression equations are subject to uncertainty. Consequently, hydrologic model outputs based on the stochastic parameters are random. The uncertainty associated with linear reservoirs (N) and storage coefficient (K) of Nash's IUH are assessed by various researchers. The uncertainty from regional regression equations is some time too significant to be ignored (Yeh et al., 1997). The assumption of the parameter K having the same value in all reservoirs is obviously unphysical as it results in the estimated value of N not being integral (Li, et al. 2008). Seong et al. (2007) proposed a practical approach to determining a regionalized Clark instantaneous unit hydrograph (IUH) model in limited data availability condition. The proposed model is described in terms of the synthetic time–area concentration curve, the concentration time, and a special regional similarity value that is valid in the whole basin. By introducing the regional similarity value into a Clark IUH, a statistically best estimate of IUH for given data conditions and its quantified degree of uncertainty were realized. Application of the model to Wi River basin in Korea showed a reliable estimation of hydrograph within the study area even with limited data availability. Considerable work has been done to estimate flood characteristics and long-term mean annual flow using regression relationships with catchment parameters in Indian, but most of these methods were developed a long time ago and may need to be revisited Jha and Smakhtin (2008). Goel (1998) presented the details of flood estimation procedures for Indian catchments in general and for mountainous watersheds in particular

8. Approved action plan and timeline

S.N.	Work Element	1st Year				2nd Year				3rd Year				Status
1	Collection of hydro meteorological data, satellite images, thematic maps etc.													Under Progress
2	Compilation, statistical analysis of rainfall and river discharge													Under Progress
3	At-site frequency analysis for point rainfall and gridded rainfall data													Under Progress
4	Regional frequency analysis for point rainfall and gridded rainfall data													Under Progress
5	Preparation of isopluvials maps for various return periods.													Yet to start
6	At-site and regional flood frequency analysis for gauged catchments													Under Progress
7	Estimation of catchment characteristics and parameters of UH													Yet to start
8	Development of regional relationships for peak floods with catchment characteristics.													Under Progress
9	Rainfall frequency relationships under climate change scenarios													Yet to start
10	Report													

9. Role of team members

S. N.	Role / Action	Member/(s)
1	Collection of hydro meteorological data, satellite images, thematic maps etc.	JPP, RK, SK, TRS
2	Compilation, statistical analysis of rainfall and river discharge	JPP, SK , TRS
3	At-site frequency analysis for point rainfall and gridded rainfall data	JPP, RK
4	Regional frequency analysis for point rainfall and gridded rainfall data	RK, JPP, SK
5	Preparation of isopluvials maps for various return periods.	JPP, RK ,PM
6	At-site and regional flood frequency analysis for gauged catchments	RK, JPP,SK
7	Estimation of catchment characteristics and parameters of UH	PM, JPP, SK

8	Development of regional relationships for peak floods with catchment characteristics.	RK ,JPP,SK
9	Rainfall frequency relationships under climate change scenarios	RK ,JPP,SK
10	Report	JPP, RK, PM, SK

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

10. Brief Methodology

This study aims at development of at-site and regional flood frequency relationships using L-moments approach for Uttarakhand state (Figure 1), perticularlly in Ganga basin up to Rishikesh. For estimation of T-year return period flood at a site, the estimate for mean annual peak flood is required. For gauged catchments, such estimates can be obtained based on the at-site mean of the annual maximum peak flood data. At-site and regional flood frequency analysis will be performed using the L-Moments approach, which includes various frequency distributions: viz. Extreme value (EV1), Generalized extreme value (GEV), Logistic (LOS), Generalized logistic (GLO), Normal (NOR), Generalized normal (GNO), Uniform (UNF), Pearson Type-III (PE3), Exponential (EXP), Generalized Pareto (GPA), Kappa (KAP), and five parameter Wakeby (WAK). Screening of the data, testing of regional homogeneity and identification of distribution will be carried out. However, for ungauged catchments at-site mean cannot be computed in absence of the flow data and in such a situation, a regional relationship between the mean annual peak flood of gauged catchments in the region and their pertinent physiographic and climatic characteristics is needed for estimation of the mean annual peak flood. For example, the form of this regional relationship may be:

$$\overline{Q} = a\, A^{b} S^{c} D^{d} R^{e}$$

Here, ($\overline{Q}$) is the mean annual peak flood, A is the catchment area, S is the slope, D is the drainage density, R is the annual normal rainfall or rainfall for the duration of annual maximum peak flood for the catchment etc., a, b, c, d, and e are the regional coefficients. Further, relationship of various other characteristics like length of main stream (L), centroidal longest flow path (L_c) etc. with peak flood will also be evaluated. The regional coefficients will be estimated using the mean annual peak floods of the gauged catchments and their pertinent physiographic and climatic characteristics for a region. The physiographic and climatic characteristics which are considered pertinent for generation of annual maximum peak floods from a catchment and can be obtained from the observed records e.g. rainfall for the duration of occurrence of the annual maximum peak floods and derived from the toposheets/maps of the gauged catchments may be considered for development of this relationship. The lengths of historical data records are very less, particularly in hilly areas. Considering this aspect frequency analysis using L-moments will be carried out using gridded rainfall data of various sources (IMD, APHRODITE) and will be compared. Regional Nash and Clark IUH models will be developed for Uttarakhand. Floods of various return periods for selected locations of Ganga basin in Uttarakhand will be estimated.

This study will also investigate the consequences of using a stationary assumption as well as the alternative: a non-stationary framework that considers temporal changes in statistics of extremes base on characteristic of time series. The estimates for various return periods using non-stationary i.e. General Extreme Value distribution with time-dependent parameters will be analysed. In addition, it is planned to analyse an ensemble of reference periods (past and future events) for rainfall frequency analysis. The future periods would be obtained various downscaled models. The NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset comprised of downscaled climate scenarios derived from the General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 5 (CMIP5) and across RCP 4.5 and RCP 8.5 from the 21 models. The spatial resolution of the dataset is 0.25 degrees (~25 km x 25 km) and the periods from 1950 through 2005 (Retrospective Run) and from 2006 to 2099 (Prospective Run). The World Climate Research Programme (WCRP) Coordinated Regional Climate Downscaling Experiment (CORDEX) dataset for South Asia region are derived from the Atmosphere-Ocean coupled General Circulation Model (AOGCM) runs conducted under the CMIP5 for RCP 4.5 and RCP 8.5. The CORDEX South Asia dataset includes dynamically downscaled projections from the 10 models for about 50 km regional climate change projections.

11. Results achieved with progress/present status

The peak annual maximum flood series data of ten gauging sites are collected from CWC (Figure 2). The box plot of annual peak flood at ten gauging sites is shown in Figure 3. At site flood frequency analysis is carried to estimated design floods of various return periods at these locations using L-moments approach. The estimated floods of 50 year and 100 year return period along with observed maximum discharge plotted against catchment area for three locations is shown in Figure 4. Further, power equation in the form of $Q_T = a_T \times A^{b_T}$ is also fitted to estimate T-year design flood (Q_T) with catchment area of known A. Daily station rainfall data of 33 raingauge stations are collected from IMD along with gridded rainfall data from 1901 to 2013. The location of raingauge stations and box plot of 1day annual maximum rainfall is shown in Figure 5. These datasets are being analysed for various statistical properties and annual maximum rainfall series are extracted for rainfall frequency analysis. The APHRODITE monsoon Asia Precipitation grided daily data from 1951 to 2007 are also downloaded. Both at site and regional rainfall frequency analysis is in progress using a stationary assumption.

The annual maximum discharge series are also being analysed for both Stationary and Nonstationary Extreme Value Analysis using GEV. The sample results at Badrinath gauging site is shown in Figure 6. However in most of the case the data series are found to be stationary at 95% confidence level.

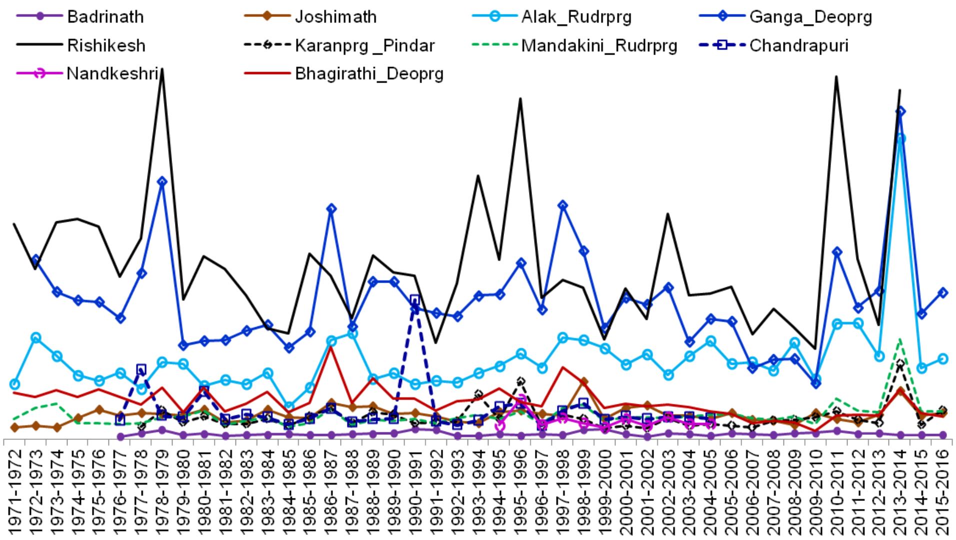


Fig. 2: Observed annual maximum flood series.

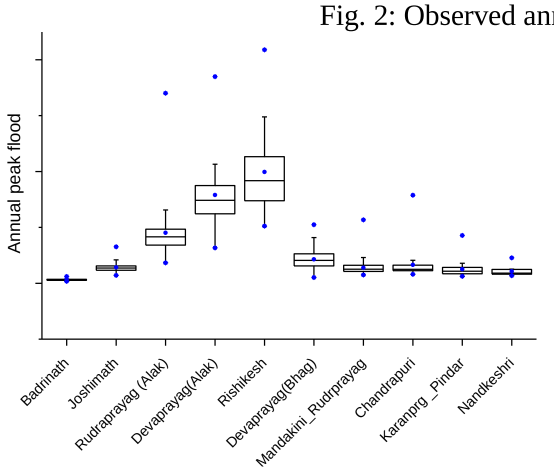


Fig. 3: Box plot of annual peak flood

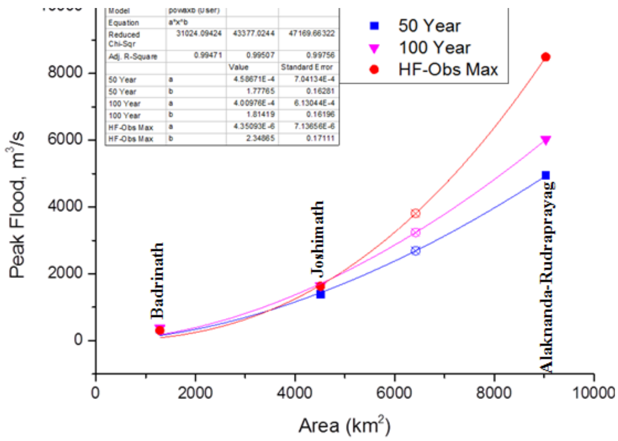


Fig. 4: Floods of various return periods

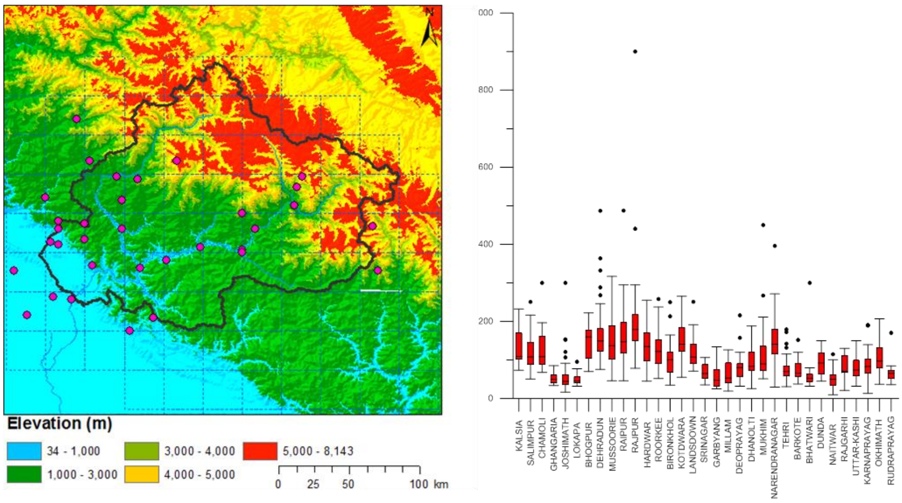


Fig. 5: Location of raingauge stations and 1 day annual maximum rainfall

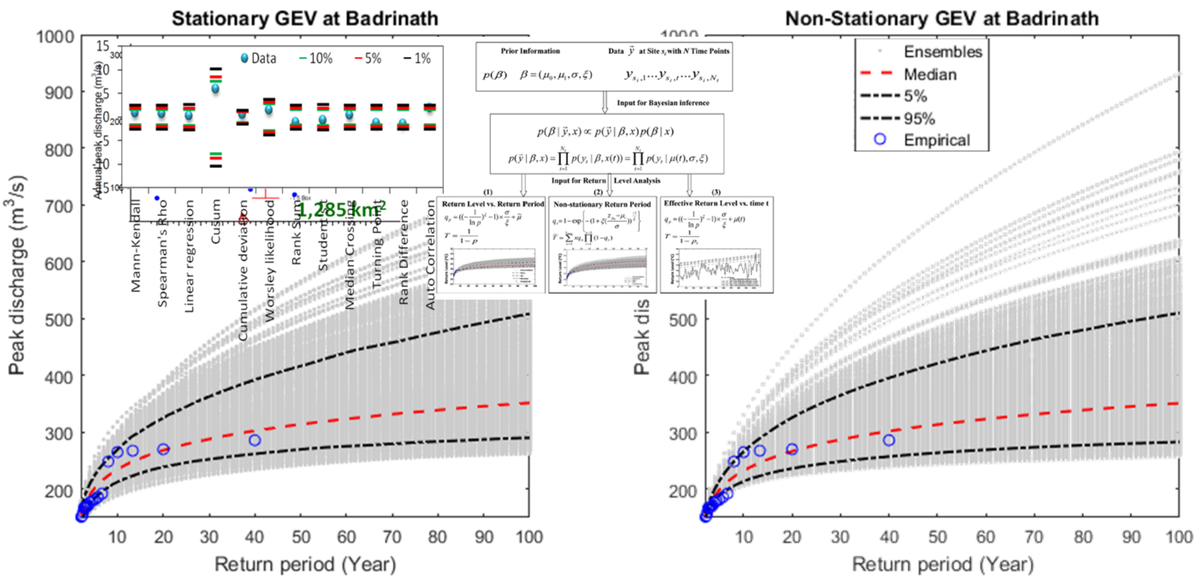


Fig. 6: Nonstationary Extreme Value Analysis using GEV at Badrinath

12. Action taken on comments of previous working group meeting

There were no specific comments.

13. List of deliverables

- Design floods of various return periods at river gauging locations.
- Isopluvial maps of various return periods (Viz. 10 year, 25 year, 50 year, 100 year etc.) for Uttarakhand.
- Assessment of usefulness and limitation of gridded rainfall data for estimation of rainfall for various return periods.
- Development of relationships between mean peak floods of various return periods with catchment characteristics.
- Research papers and reports.

14. Data collected/generated

- ♦ DEM of the study area is 90 m SRTM and 30 m CartoSat.
- ♦ Peak annual maximum flood series for ten gauging sites.
- ♦ 0.25 x 0.25 deg grided daily rainfall data from 1901 to 2013 from IMD
- ♦ 0.5° and 0.25° grided, daily data from 1951 to 2007 from APHRODITE monsoon Asia Precipitation data.
- ♦ Daily rainfall data of 33 raingauge stations.

15. Involvement of end users/beneficiaries

The study has been proposed with after discussion with Irrigation department of Uttarakhand. It is expected that outcome of study will be helpful for estimation of design floods for various water resources projects.

7. Evaluation of seasonal extreme rain events across river India in 3D global temperature change

PROJECT REFERENCE CODE: NIH/SWHD/18-21

Title of the Project: **Evaluation of seasonal extreme rain events across river basins of India in 3D global temperature change scenario'**

Project team: Dr. Ashwini Ranade, Scientist 'C'(PI)
Dr. Archana Sarkar. Scientist 'D'(Co-PI)

Type of Study: Internal

Status: ongoing

Duration: 3 years

Date of Start: 1 April 2018

Scheduled date of completion: 31st March 2021

Objectives

Sr. No.	Objectives	Status
1.	Updation of longest instrumental area averaged monthly rainfall series (1813-2000) of 11 major and 9 independent minor river basins of India and to document climatological and Fluctuation features of annual, seasonal and monthly rainfall	Completed
2.	Identification of different types of seasonal extreme rain events concerning rainfall amount, rainfall intensity and duration over seven homogenous rainfall zones of India during 1951-2015.	Ongoing
3.	Evaluation of 3D global atmospheric parameter changes conducive for the occurrence of large-scale extreme rain events over seven homogeneous rainfall zones during different seasons.	Ongoing
4.	Time series modeling of the longest instrumental monthly rainfall series (1813-2015) of major and independent minor river basins for their extrapolation for 2 to 10 years	Ongoing

Statement of the problem

Heterogeneous changes in global tropospheric temperatures over the last few decades have been observed to make changes in spatiotemporal distribution of rainfall across the globe. Annual, seasonal, and monthly rainfall across India shows strong spatiotemporal variation and large departures from normal. Many of the studies show an overall decreasing trend in monsoonal rainfall over a major part of the country. However, in our earlier studies, we did not find any significant long term trends in wet season parameters of 11 major and 36 minor basins, but noticed a declining tendency in wet season rainfall in some major basins of the Central India. In a monsoon season, extreme events occur surprisingly even during large-scale drought years also. So there is pressing need in hydrology, to better understand the ongoing changes in hydro-meteorological extremes in order to comprehend the impact of climate change on water resources in different parts of the country. Recent understanding through global climate models predicts that, the hydrological cycle will accelerate as climate warms, and leads to changes in patterns of extreme floods and droughts. We have seen that, the small-scale, short-duration EREs are embedded in large-scale, long-period intense wet spells, and rainwater generated during the main monsoon wet period is highly correlated with the Asia-Pacific monsoon intensity. Abrupt warming and cooling in the atmosphere drastically modulates the monsoon circulation and intensify the associated weather systems causing heavier rains over a region. Types of weather systems and general and monsoonal circulation associated with the occurrence of extreme rain events in different parts of the country could be different.

Keeping in mind recent changes in global surface temperature, monsoon circulation pattern, and occurrence of EREs, the aim of the present study is to understand the nature of short-term to long-term rainfall variability across river basins of India using the area averaged longest instrumental basin scale rainfall dataset (1813-2015) and to determine the causal factors of the dominant modes of its variability.

Dataset used and Study area:

For the present report classification of the country's river systems into major and minor basins by K. L. Rao (1975) is adopted. 11 Major basins and 9 independent minor river basins are selected for the updation of monthly rainfall series up to 2015.

The longest instrumental area-averaged monthly rainfall series for 11 major river basins and 36 minor river basins earliest from 1813-2000 is used and updated up to 2015 using 1 degree gridded daily rainfall data from India Meteorological Department from 1951-2015. Atmospheric variables (Temperature, Geopotential height, mean sea level pressure, precipitable water etc.) from 'Climate System Forecasting (CFSR) reanalysis dataset.

Analysis and results:

Longest instrumental area averaged basin-scale monthly rainfall series for 11 major basins, 9 independent minor basins, west coast drainage system and for the whole country available from 1813 (starting year for each basin is different) to 2000 has been updated from 2001 to 2015 in this study. The rainfall series available earliest from 1813 to 2015 have been developed in three different phases.

1. In the first phase, for the period 1901 to 2000, simple arithmetic mean of all available gauges in the basin from fixed well spread instrumental network of 316 raingauge stations have been used.
2. In second phase the dataset has been extended backward from 1900 to 1813 by applying theoretically vindicated numerical method on limited available observations (Sontakke and Singh, 1996).
3. In the third phase, the dataset has been updated by using 1-deg gridded daily rainfall with the ratio method suggested by Rainbird (1967) and approved by WMO.
4. In the first two phases, station datasets were used for the construction, while in third phase, each station value has been extracted from the corresponding value of the grid from the gridded rainfall dataset.

1. Annual Rainfall characteristics of Major and Minor basins

Climatological and fluctuation features of the monthly and seasonal (Jan-Feb, March-April-May, June-July-Aug-Sept and Oct-Nov-Dec) and annual rainfall of all the time series have been calculated and documented. Normally the mean annual rainfall of 11 major river basins varies from 742.8mm over Sabarmati to 2478.3mm over Brahmaputra. The WCDS gets 2528.5 mm annual rainfall in normal year. The coefficient of variation of the annual rainfall varies from 9.6% (Brahmaputra) to 36.2% (Sabarmati). The year-wise highest rainfall normally varied between 1116.4 mm (Krishna) and 3161.6mm (Brahmaputra), while that of lowest from 248.9mm (Sabarmati) to 1979.2mm (Brahmaputra).

For 9 independent minor basins, the normal annual rainfall varies from 487.7 mm over Luni basin to 2519.5 mm over Surma basin. The coefficient of variation varies from 12.1%(Surma) to 37.4% (Luni). The year-wise highest annual rainfall was for Surma (3352.5mm) and the lowest for Luni 9167.5mm).

For the country as whole, All India gets 1165.9mm rainfall annually with the highest rainfall as high as 1435.3mm and as low as 895.7mm.

2. Chief fluctuation features in Monsoon rainfall:

Inter-annual variations in annual, seasonal and monthly rainfall are filtered with 9-point filtering technique to understand the low frequency variability. The smoothed series indicate many aperiodic fluctuations and wet and dry epochal patters. Seasonal and annual rainfall condition of a particular year are categorized as very dry, moderately dry, normal, moderately wet and very wet by using quintiles as a threshold calculated from the dataset of 1901-2000.Categorized rainfall time series for all basins have been prepared and analyzed. Fig.1 shows the rainfall time series for Brahmaputra and Cauvery major basins and the table 1 gives the listing of major epochal periods in monsoon rainfall of all basins documented after visual examination of filtered time series.

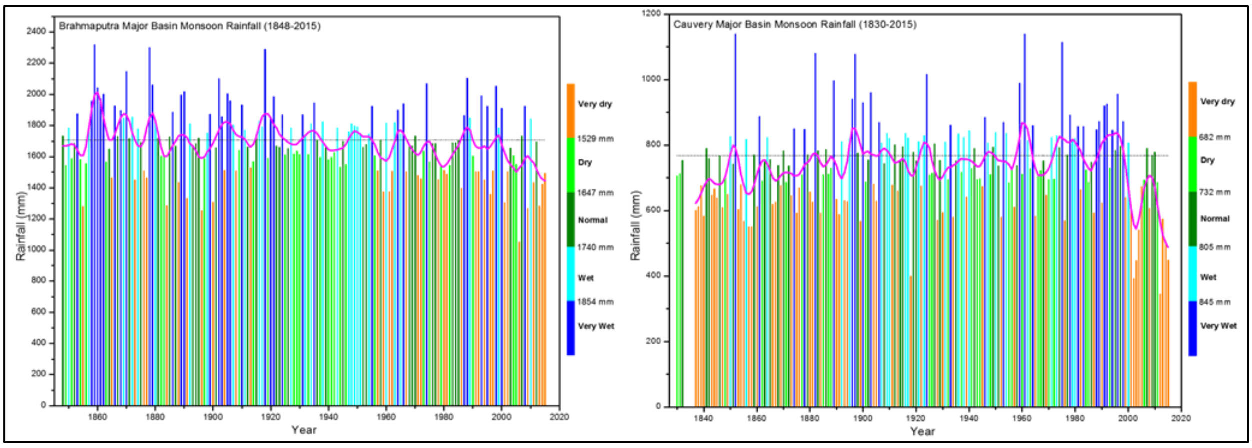


Fig.1 Inter-annual variations of Summer Monsoon rainfall over Brahmaputra and Cauvery river basins

Table 1. Major epochs in monsoon rainfall of river basins

Sr. No.	**Basin Name**	**Epochs in monsoon rainfall fluctuation (w: wet; d: dry; f: fluctuating)**
	Major Basins	
1.	Indus majo	1813-1828 (f), 1829-1860 (d), 1861-1896 (w), 1987-1908 (d), 1909-1931 (f), 1932-1963 (w), 1964-1998 (f), 1999-2015 (d)
2.	Ganga major	1829-1953 (d), 1854-1898 (w), 1899-1914 (d), 1915-1926 (w), 1927-1932 (d), 1968-2000 (f), 2001-2015 (d)
3.	Brahmaputa major	1848-1881 (w), 1882-1901 (d), 1902-1925 (w), 1926-1954 (f), 1955-2015 (d)
4.	Godavari Major	1854-1878 (d), 1879-1896 (w), 1897-1906 (d), 1907-1916 (w), 1917-1930 (d), 1931-1964 (w), 1965-2008 (d)
5.	Krishna major	1836-1879 (d), 1880-1897 (w), 1898-1906 (d), 1907-1916(w), 1917-1952(d), 1953-1966(w), 1974-2015 (f)
6.	Sabarmati	1861-1877 (d), 1978-1896 (w), 1897-1904(d), 1905-1909 (w), 1910-1924 (d), 1925-1961 (w), 1962-2003 (d), 2004-2015 (w)
7.	Mahi	1857-1896 (w), 1897-1940 (d), 1941-1962 (w), 1963-1969 (d), 1970-1979 (w), 1980-2003 (d), 2004-2015 (w)
8.	Narmada	1844-1865 (d), 1866-1896 (w), 1897-1929 (d), 1930-1950 (w), 1951-2015 (f)
9	Tapi	1859-1874 (d), 1975-1894 (w), 1895-1929 (d), 1930-1949 (w), 1950-2004 (f),
10.	Mahanadi	1851-1862 (w), 1863-1879 (d), 1880-1897 (w), 1998-1925 (f), 1926-1963 (w), 1964-2015 (d)
11.	Cauvery	1837-1894 (d), 1895-1911 (w), 1912-1958 (d), 1959-1964 (w), 1965-1972 (d), 1973-1998 (w), 1999-2015 (d)
12.	WCDS	1816-1832 (f), 1933-1921 (d), 1922-2015 (f)
13.	All India	1813-1869 (d), 1870-1896 (w), 1897-1914 (d), 1915-1931 (f), 1932-1998 (w), 1999-2015 (d)
Independent Basins		
14.	Luni	1856-1895 (f), 1896-1906 (d), 1907-1941 (f), 1942-1961 (w), 1962-1971 (d), 1972-1979 (w), 1979-1989 (d), 1990-1997 (w), 1998-2005 (d), 2006- 2015 (w)
15.	Surma	1862-1887 (f), 1888-1902 (d), 1903-1923 (f), 1924-1990 (w), 1991-2015 (d)
16.	Kasai	1868-1879 (d), 1880-1905 (f), 1906-1928 (w), 1929-1937 (d), 1938-1951 (w), 1952-1968 (d), 1969-1983 (f), 1984-1997 (w), 1998-2015 (f)
17.	Damodar	1828-1939 (d), 1840-1853 (f), 1854- 1971 (w), 1972-1896 (d), 1997-1936 (f), 1937-1944(w), 1945-1967 (d), 1968-2001 (w), 2002-2015 (d)
18.	Suvarnarekha	1859-1874 (d), 1875-1897 (w), 1898-1918 (d), 11919-1945 (w), 1946-1968 (f), 1969-1978 (w), 1979-1988 (d), 1989-2015 (w)
19.	Brahmani	1879-1948 (w), 1949-1986 (d), 12987-1995 (w), 1996-2015 (d)

20.	Pennar	1813-1837 (d), 1938-1848 (w), 1849-1868 (d), 1969-1879 (w), 1879-1887 (d), 1888-1898 (w), 1899-1907 (d), 1908-1918 (w), 1919-1954 (d), 1955-2015 (w)
21.	Pallar & Ponniyar	1863-1870 (d) 1871-1925 (w), 1926-1955 (d), 1956-1998 (w), 1999-2015 (d)
22.	Vaigai	1846-1862 (w), 1863-1884 (d), 1985-1924 (w), 1925-1945 (d), 1946-1976 (w), 1975-2004 (d), 2005-2010 (w), 2011-2015 (d)

3. Short-term and Long-term rainfall variability

The Cramer's t_k statistics (WMO 1966) has been applied to moving averages of each of the time series to determine the broad nature of (+ve and –ve) short-term tendencies (15-year), medium-term fluctuations (31-year), long-term trend (51-year), and secular trend (101-year). The t_k is calculated and significance is tested for times series of all major and independent minor river basins. The test compares the means of the sub-periods to the mean of the entire record. Visual examination revels that the monthly, seasonal and annual rainfall is found to exhibit wide range of fluctuation characteristics across the country. Significant increasing trend is noticed in recent 101 years (1915-2015) in monsoon rainfall over Krishna major (2.7%), Tapi (3.6%), WCDS (2.3%) and the whole country (1.4%) compare to preceding instrumental period. Brahmaputra major, Mahi, Mahanadi, Brahmani, Pallar and Ponnaiyar showed non-significant decreasing trend.

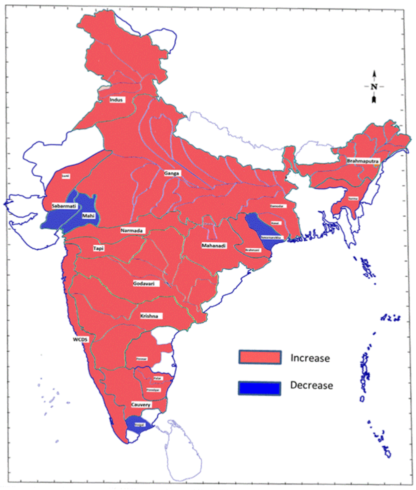


Fig.2 Recent year changes (1999-2015) in Monsoon rainfall relative to latest wet period (1988-1998)

Recent year changes (1999-2015) in seasonal rainfall of all basins, All India and west coast drainage system relative to last wet period (1988-1998) monthly record have also been tested. It has been seen that, for most of the basins, the period 1999-2015 was drier (except Sabarmati, Mahi, Suvarnarekha and Vaigai) compare to preceding wet period of 1988-1998. For the whole country, monsoon rainfall was -6.4% below normal during 1999-2015 compare to preceding wet period of 1988-1998 (Fig 2)

4. Recent year changes in global thermal structure:

Detailed analysis is carried out in order to understand the climatological and fluctuation features of the three-dimensional global thermal field and recent year changes in global thermal structure in the backdrop of climate change scenario. The NCEP-NCAR: CDAS-1 global monthly reanalysis product of atmospheric temperature at 12 isobaric levels from 1949-2013 at 2.5 ^{o} X 2.5 ^{o} scale is used. Climatologically the annual tropospheric temperature decreases from equator to pole in lower, middle and upper troposphere while the gradient reverses in upper troposphere-lower stratosphere. The equator is the least variable climatic zone and south pole is the coolest zone in the troposphere. The mean annual interhemispheric temperature contrast (NH-SH) across the globe increases poleward away from equator. It is positive throughout the year in lower (LTT: 1000-700hPa), middle (MTT: 600-500hPa) and upper troposphere (UTT: 400-250hPa), but is negative for tropics and subtropics in upper troposphere-lower stratosphere (UTLS: 200-100hPs) layer. It indicates that, normally the NH is having warmer troposphere compare to SH on annual basis. On annual scale, NH-SH contrast is positive only over temperate, subpolar and polar climate zones. The largest contrast is seen over the poles.

In recent 35 years the LTT has increased significantly all across the globe with the exception of south sub pole and pole, the LTT has decreased significantly. The N-S temperature contrast between the climatic zones across the globe has shown significant decrease during most of the seasons. While that of between N-S sub pole and pole has shown significant increase. The MTT temperature across the globe has shown significant increase in all seasons in recent 35 years. The N-S subtropics and N-S temperature contrast in all seasons and N-S sub pole and N-S pole contrast during JJAS have decreased significantly. In upper troposphere, most of the climatic zones have shown significant increase in their temperatures in recent years while the inter-hemispheric contrasts between them are decreased significantly mostly for subtropics, temperate and subpolar regions. In UTLS, the significant increase in temperature has been noticed for equator, tropics and subtropics of both hemispheres, while rest of the climatic zones show significant decrease in their temperatures in recent years. The interhemispheric contrast in all climatic zones have shown significant decrease in all seasons. In recent 35 years, equator and south tropics does not show any changes in the seasonality throughout the troposphere. The north temperate, subpolar and polar regions show significant decrease in the seasonality in lower troposphere while those of SH shows significant increase.

Important results so far:

- Normal (1901-2000) annual rainfall of the river basins across the country varies from 487.7mm (Luni) to 2519.5mm (Surma). Normal annual rainfall of the country is 1165.9mm, highest rainfall of 1435.3mm occurred during year 1917 and 895.7mm during year 1918.
- Significant increasing trend is noticed in recent 101 years (1915-2015) in monsoon rainfall over Krishna major (2.7%), Tapi (3.6%), WCDS (2.3%) and the whole country (1.4%) compare to preceding instrumental period. Brahmaputra major, Mahi, Mahanadi, Brahmani, Pallar and Ponnaiyar showed non-significant decreasing trend.
- During recent 15 years (2001-2015), monsoon rainfall over Ganga major is decreased significantly by 7.4%, Brahmaputra major 10.5% and Cauvery 19.8% relative to entire available instrumental records.
- Compare to 20th century (1901-2000) monsoon rainfall over basins in northeast India, central northeast India, northwest India, and south peninsular India has been lesser while that over central northwest India, north peninsular India and north India in recent 15 years (2001-2015).
- For the whole country, the period 1998-2015 was drier by 5.4% compare to preceding wet period of 1988-1998.
- In recent 35 years the LTT has increased significantly all across the globe with the exception of south sub pole and pole, MTT across the globe has increased significantly during all seasons, UTt has increased over most of the zones while UTLS shows significant increase only over equator, tropics and subtropics of both hemisphere.

Deliverables

It is expected that the results from this study will be useful for water resource management and regional hydrological modelling across India.

Adopters of the results of the study and their feedback:

From hydrology and water resources sectors

Major items of equipment procured: None
Lab facilities during the study: None
Specific linkages with Institutions/beneficiaries: None
Shortcomings/Difficulties:

1. Shortage of observed station rainfall data for the updation of longest instrumental monthly rainfall series
2. Shortage of manpower

Future Plan:

To understand the effect of climatic changes in global atmospheric parameters and circulations on extreme rainfall of river basins of India

8. Assessment of Climate Change Impact on Water Availability and Agriculture in part of Banas basin

PROJECT REFERENCE CODE: NIH/SWHD/NIH/18-20

Title of the Study-: **Assessment of Climate Change Impact on Water Availability and Agriculture in part of Banas basin**

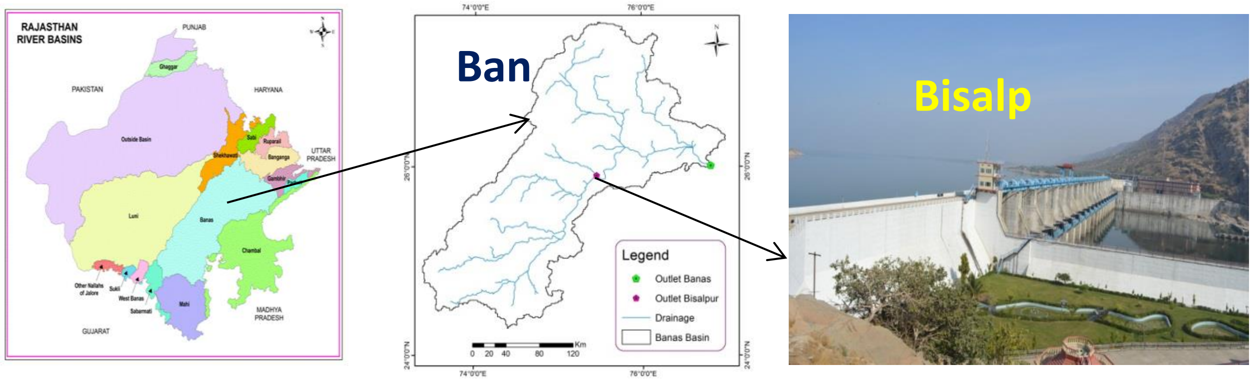
Study Team Dr. Archana Sarkar, Sc D, SWHD (PI)
Dr. Surjeet Singh, Sc E, GWHD (Co-PI)
Ms. Suman Gurjar, Sc C, GWHD
Mr. Sunil Gurrapu, Sc C, SWHD

Type of Study-: Internal
Date of Start : 1 Nov. 2018

Scheduled date of completion: 31 Oct. 2020

Study Area:

The study area is the Banas river basin up to the Bisalpur Dam and command area in Rajasthan.



River Banas is located in east-central part of Rajasthan State in India. It originates in the Khamnor hills of the Aravali range and flows in Rajasthan. Banas is a major tributary of the River Chambal, which is again a tributary of River Ganga. The total catchment area is about 51,779 km2 with a length of about 512 km. The Banas River passes through the 13districts namely, Sawai Madhopur, Jaipur, Ajmer, Tonk, Rajsamand, Banswara, Chittaurgarh, Udaipur, Bhilwara, Dausa, Sikar, Nagaur and Karauli. The Banas Basin may be classified as tropical grassy plains, semi-arid and hot, on the basis of Koppen's classification of climatic patterns. Orographically, the western part of the Basin is marked by hilly terrain belonging to the Aravali chain. East of the hills lies an alluvial plain with a gentle eastward slope. Ground elevations in the western hilly part range approximately 900 meters, while the alluvial plain elevations range approximately from 650 meters. The mean annual rainfall over Banas Basin is around 585 mm of which about 95% falls during the four Monsoon months (June-September). The average temperature in the basin varies from 19°C to 33°C with the maximum going above 45°C during summers.

Study Objectives:

1. Analysis of the historical & future patterns of rainfall and temperature in Banas basin up to Bisalpur Dam and command area.
2. Rainfall-runoff modelling in the catchment of Bisalpur dam.
3. Estimation of inflow and water availability in Bisalpur reservoir.
4. Assessment of irrigation demands in the command area of Bisalpur dam.
5. Scenario analysis of future water availability under climate change and measures to address the gaps in supply-demand scenario.

Statement of the problem:

The Banas River Basin is the largest river basin (45833 km^2) within the Rajasthan State of India. Banas is a seasonal river that dries up during the summer, but it is nonetheless used for irrigation. Bisalpur drinking water cum irrigation project is constructed across river Banas in 1991 with an ultimate irrigation potential of 55224 hectare (irrigation during the months of October to March for the Rabi crop), besides providing 458.36 million m^3 of drinking water for Jaipur, Ajmer, Beawar, Kishangarh, Nasirabad and other enroute cities, towns and villages. An estimated 150 million USD of extra agriculture was produced in 2014-2015. An increase in temperature in this region has been observed from historical data. This may lead to shortening of the crop growth period, increase in crop water requirement and reduction in crop yield. The water availability in this reservoir in coming years will play a crucial role in the overall economy of the entire region including other socio-economic issues.

Approved Action plan and timeline

S. No.	Work Element	First Year				Second Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Collection of information and Hydro-meteorological data from field, Preparation of base maps								
2	Trend analysis of historical data								
3	Downloading and bias correction of GCM data								
4	Input data preparation for Rainfall runoff model and CROPWAT								
5	**Preparation of Interim Report**								
6	Calibration and Validation of rainfall runoff model								
7	Assessment of crop water requirement for the present cropping pattern using CROPWAT								
8	Inflow forecasting for the Bisalpur Dam								
9	Climate change scenario analysis for future water availability								
10	Climate change scenario analysis for future crop water requirement								
11	Recommendations to address the gaps in future water availability-demand scenario								
12	Preparation & Submission of **Final report**								

Progress

Objectives	Achievements
Nov 2018- Feb 2019	
Collection of information and Hydro-meteorological data from field, Preparation of base maps	Partially completed
Trend analysis of historical data	Partially completed
Downloading and bias correction of GCM data	In progress

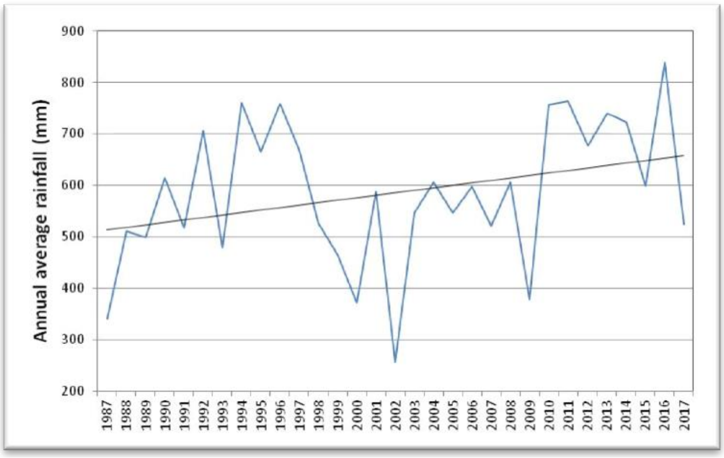
Analysis and Results

Data Used

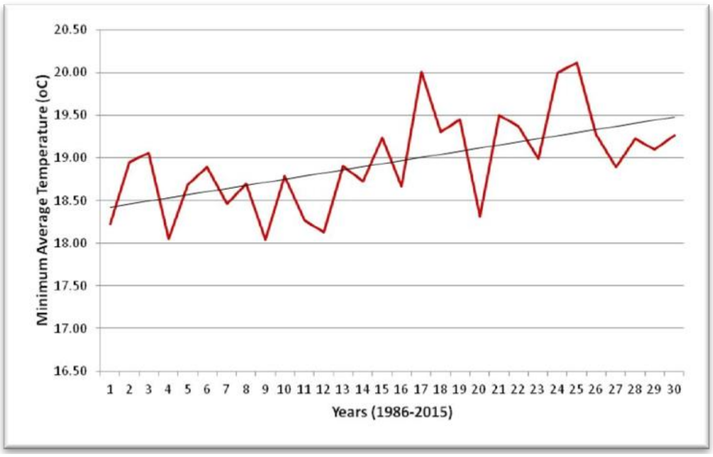
Daily rainfall data of 28 raingauge stations for a period of 30 years (1987- 2016) and daily gridded temperature data at 1^{o}X1^o of 30 years (1986-2015) for the Banas River basin.

Results

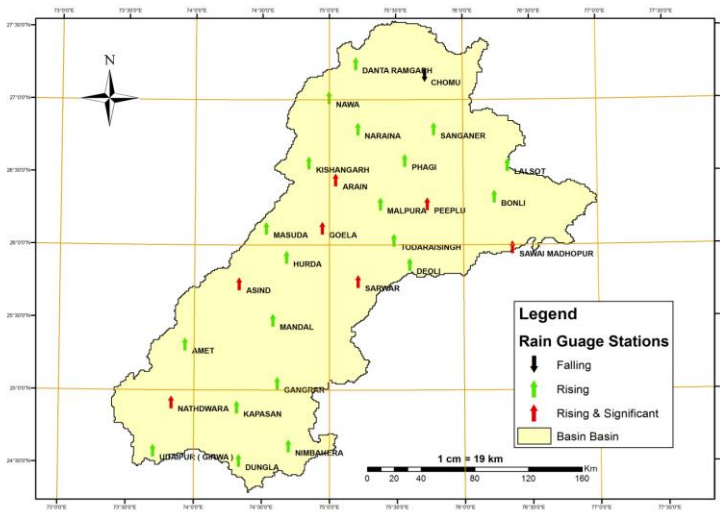
Trend analysis has been carried out with daily precipitation and daily temperature (max, min, mean) data on annual scale. Seasonal and monthly analysis of trends is being carried out.



Temporal variation of the annual average precipitation in Banas basin



Temporal variation of the Minimum average temperature in Bisalpur dam command area



Trends of Annual Rainfall in Banas Basin

Expected Adopters

Water Resources Department, Agriculture Department, Govt of Rajasthan.

The methods and results generated in the present study will help the Water Resources Department and Agriculture Department of Rajasthan State for the assessment of impacts of climate change in the basin and develop policies accordingly for the improved water resources management and best agricultural practices.

Deliverables

Research papers, report, stakeholder engagement

Data Procured and/Generated during the Study

Daily rainfall data of 28 raingauge stations in the Bisalpur River basin for a period of 30 years (1987-2016). Gridded temperature data at $1^{o}X1^{o}$ for the Banas basin from IMD (previously procured for other study), Essential climate variables (precipitation, temperature) at 0.5deg resolution from ECMWF

Future Plan

As per the approved action plan.

9. Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent

PROJECT REFERENCE CODE: NIH/SWHD/18-21

Title of the Project: Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent

Project team: Mr. Sunil Gurrapu, Scientist C (PI)
Dr. Ashwini Ranade, Scientist C
Mr. Jagadish Prasad Patra, Scientist C

Type of Study: Internal

Status: On-going

Duration: 3 years

Date of Start: 1st November 2018

Scheduled date of completion: 31st October 2021

Objectives:

1. Analyze annual peak flows in the rivers of Indian subcontinent.
2. Evaluate the influence of various low-frequency atmosphere-ocean oscillations on flood magnitude and frequency.
3. Sensitivity analysis of probable maximum precipitation (PMP) estimation methods in flood frequency studies.
4. Prepare a status report on the impact of changing climate on PMP in India.

Statement of the problem:

Globally, floods are ranked among the largest and costliest natural disasters having major impact on various economic sectors. In India, flooding is one of the three prominent climate extremes, other two being droughts and cyclones. Majority of flooding in Indian watersheds occurs during summer monsoon months due to uneven distribution of rainfall. For example, recent devastating floods in Kerala were in response to the abnormally high rainfall received within a short period of 3 days, i.e. during 15th to 17th August 2018. Summer monsoon rainfall being the major source of water input to the Indian subcontinent, optimal design and operation of water resources infrastructure (e.g. major dams) is very much essential. Planning and design of such structures require a great depth of knowledge on the magnitude and frequency of extreme floods. Traditionally, the frequency of extreme floods is derived based on the analysis of historically observed annual maximum flows assuming they are independent and identically distributed (i.i.d) and the system fluctuates within a fixed envelope of variability, i.e. stationarity assumption. However, several studies across the globe highlight the potential inadequacy of traditional flood frequency analysis (FFA) and argue that the i.i.d. assumption can no longer be considered valid. Moreover, Indian summer monsoon is influenced by several low-frequency atmosphere-ocean oscillations including Atlantic Multidecadal Oscillation (AMO), Pacific Decadal Oscillation (PDO), El Niño-Southern Oscillation (ENSO) etc.

The failure probability of large hydraulic structures such as large dams and spillways, should be as low as possible. BIS specifies that the design flood for a large structure (i.e. gross storage > 60 MCM) is the probable maximum flood (PMF). The design flood for such structure is estimated based on the probable maximum precipitation (PMP). PMP is the maximum precipitation that is physically possible over a region for a given duration. PMP can be estimated either from meteorological or statistical methods. However, due to lack of standard approach for estimating PMP, it's use in the design and analysis of flood related studies is criticized. In this study, we propose to first analyze the annual floods (i.e. maximum flows) with the hypothesis that they are influenced by the low-frequency atmosphere oscillations originating in the equatorial Pacific and Indian Oceans. Secondly, we propose the evaluate the PMP estimation methods in flood frequency studies and prepare a status report on the impact of climate change on PMP.

Study Area (Preliminary):

The preliminary study is being carried out on several sub-basins of River Godavari and River Narmada. We chose several streamflow gauging stations with a minimum of 30 years observed daily streamflow data. Based on the preliminary survey of available streamflow data, we chose 19 gauging stations from Godavari and 12 stations from Narmada watersheds, with at least 30 years of data.

Datasets:

1. Observed daily streamflow data for the selected gauging stations is obtained from India-WRIS website.
2. Pacific Decadal Oscillation (PDO) indices is obtained from Joint Institute for the study of Atmosphere and Ocean (JISAO), University of Washington.
3. El Niño-Southern Oscillation (ENSO)is quantified by Southern Oscillation Index (SOI) and is obtained from Climate Research Unit, University of Eastern Anglia.
4. Indian Ocean Dipole is quantified by the Dipole Mode Index (DMI) and is obtained from Earth Systems Research Laboratory (ESRL), National Oceanic and Atmospheric Administration (NOAA), USA.

Current Status:

This study was motivated by the observation that the influence of low frequency oscillations upon flood risk is not yet a key ingredient in the planning and design of regional infrastructure, despite several studies showing strong correlations between monsoon rainfall and low frequency oscillations such as ENSO, PDO etc. This study will be the first to evaluate the impact of these teleconnections on annual floods in the watersheds of Indian subcontinent. To expand the scope of this project, we added an additional objective, i.e. to analyze the sensitivity of PMP estimating methods in flood frequency studies. The PMP is used in the estimation of design flood for large-scale projects, and hence it is imperative to understand the effect of the changing climate on PMP estimation. In this context, we also propose to prepare a status report on the impact of climate change on PMP in India.

We obtained the daily streamflow data for several gauging stations (19 in Godavari basin and 12 in Narmada basin) from India-WRIS. These stations were selected based on the length of the record, i.e. at least 30 years of observed data. Annual peaks were extracted for the water year (1st June to 31st May of the following year), with a condition that at least 200 days of flow data is available during both southwest (June – September) and northeast (October – December) monsoon seasons, i.e. a maximum of 14 days of missing data is allowed during the water year. Despite the risk of missing out on few peaks, we adopted this condition to include as many stations as possible in the study. After preliminary evaluation of daily streamflow hydrographs, we analyzed the distribution of annual peak flows. We then evaluated the correlations between annual peak flows and the PDO indices. Although the correlations are stronger and significant for few stations, they are not significant for all the stations. One major shortcoming is the length of the available data, the periodicity of PDO is approximately 20 - 30 years and hence the weak signal of PDO in annual peak flows. Longer duration datasets would help identifying the signal clearly and time-lag analysis would help us evaluate the temporal dynamics. Currently, we are identifying gauges with longer records and also reviewing other strategies to evaluate the PDO signal on annual peaks in these watersheds. Continuing the analysis further, we analyzed the correlations between more frequent ENSO and the annual floods. The correlations are stronger and statistically significant in the majority of the gauging stations analyzed. We are evaluating these correlations further to identify spatial and temporal variability. Consecutively, we will also evaluate the impact of other teleconnection. We are also reviewing the available literature to evaluate the PMP estimation methods in the context of the changing climate and a status report will be prepared for the same.

Deliverables:

1. Research papers based on the established relations between low-frequency climate oscillations and flood magnitude and frequency.
2. Status report on the impact of climate change on probable maximum precipitation (PMP) in India.

10. Evaluation of Water Quality of Government Schools in Roorkee Block, District - Haridwar

PROJECT REFERENCE CODE: NIH/SWHD/18-20

Title of the Study: Evaluation of Water Quality of Government Schools in Roorkee Block, District Haridwar

Study Group: PI: N. K. Bhatnagar, Scientist B
Co-PI: Dr. M. K. Sharma, Scientist D
Dr. L. N. Thakural, Scientist C
Smt Reena Rathore, Deputy Education Officer, Roorkee Block

Role of Team Members:

S. No.	Name of the person	Role
1	N. K. Bhatnagar	• Meetings with School authorities: List of Schools, fixing the schedules of schools visit for sampling, discussions about mass awareness programmes for schoolchildren and villagers etc • Preparation of study area map • Preparation of route map for sampling • Literature review including the work of NIH in district Haridwar • Pre- and Post-monsoon Groundwater Sampling • Processing of data • Organization of Mass Awareness Programme • Preparation of report
2	M. K. Sharma	• Guidance, Supervision and review of the work • Pre- and Post-monsoon Groundwater Sampling • Water quality analysis • Processing of data • Organization of Mass Awareness Programme • Preparation of report
3	L. N. Thakural	• Guidance, Supervision and review of the work • Data base preparation in GIS environment • Organization of Mass Awareness Programme • Preparation of report
4	Smt Reena Rathore Deputy Education Officer, Roorkee Block	• Providing support, supervision and help regarding Schools. • Organization of Mass Awareness

Type of Study : Applied research

Date of start : October 2018

Scheduled date of completion: September 2020

Duration of the Study: 2 Years

Objectives of the Study: i) Groundwater quality monitoring in pre-monsoon (April-May) and post-monsoon (OctoberNovember) season at identified school locations. ii) To map degraded ground water quality zones and possible sources of pollution and identify specific parameters not conforming to drinking water quality standards. iii) To examine the suitability of ground water quality for drinking purpose using Water Quality Index. 145 iv) To suggest ameliorative measures to restore the quality and sustainable use of groundwater for drinking.

v) To organize Mass Awareness Programme for school and villagers regarding Drinking Water Quality and Water Conservation.

Statement of the Problem: Groundwater is one of the vital resources, which meets the requirements of daily livelihood especially in rural areas of India. Growing demand of water in various sectors viz; agriculture, industrial and domestic sectors, has brought problems of over-exploitation of the groundwater resource, continuously declining groundwater levels, sea water ingress in coastal areas, and groundwater pollution in different parts of the country. There is a major possibility that School Children of Roorkee Block are bound to drink contaminated water as informed by Deputy Education officer, Roorkee Block during a talk. In view of this, a study was conceptualized to evaluate the groundwater quality status of Government Schools of Roorkee for drinking purpose.

Action Plan/Methodology: i) Literature survey on assessment of groundwater quality and issues in the region. ii) Meetings with School authorities: List of Schools, fixing the schedules of schools visit for sampling, discussions about mass awareness programmes for schoolchildren and villagers etc iii) Preparation of study area map iv) Preparation of route map for sampling v) Collection of groundwater samples from selected sources in pre-monsoon (April-May) and post-monsoon (October-November) season at identified locations. vi) Analysis for physico-chemical parameters: pH, EC, TDS, Alkalinity, Hardness, Major Cations (Na, K, Ca, Mg), Major Anions (HCO3, Cl, SO4, NO3), Minor Ions (F, PO4,) and Toxic (Heavy) Metals: As, Cd, Cr, Pb, Cu, Ni, Fe, Zn, Mn in the collected water samples. vii) Processing of hydro-chemical data for pre- and post-monsoon seasons as per BIS and WHO standards to examine the suitability of ground water for drinking purpose. viii) Spatial distribution map will be prepared in the form of contour diagrams to identify degraded water quality zones, possible sources of pollution and specific parameters not conforming to drinking. ix) Suggesting ameliorative measures to control/ restore the groundwater quality.

Timeline:

Year	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter
2018-19			Literature Survey	Meetings with School authorities, Preparation of Maps, Interim report.
2019-20	-. Field visit, Sampling.	Sample Analysis and processing of the data.	Field visit, Sampling.	Analysis and processing of the data, Interim Report.
2020-21	Mass Awareness Programme	Preparation of Final Report.		

List of deliverables: Technical Report and Research

Lab facilities during the study: Water Quality and Remote Sensing/GIS Laboratory of NIH

Data generated in the study: Hydro-chemical and statistical data of Roorkee block.
Study Benefits/Impact: Water quality analysis of every school will be helpful to provide pure potable drinking water to schoolchildren and they wouldn't be bound to drink contaminated water that will be helpful them not to fall ill because of water born diseases. Directly the health of children will improve and, consequently, the attendance too.

Specific linkages with Institutions/beneficiaries: Villagers, Education Authority of District Haridwar and District Administration /Difficulties: None.

Expected Budget

Sr. No.	Sub-Head	I Year	II Year	Total
1	Travelling expenditure	100000	100000	200000
2	Infrastructure / Equipment / Consumable	100000	100000	200000
3	Experimental charges	350000	350000	700000
4	Misc. Expenditure	50000	50000	100000
5	Grand Total	600000	600000	1200000

Progress after last working Group:

As scheduled in timeline, Literature survey on water quality of Haridwar has been done, study area map with the help of GIS is under preparation, Interim report will be prepared on the completion of 6 months.

11. Development of Drought Monitoring System for early warning and preparedness for a selected region in India

PROJECT REFERENCE CODE: NIH/SWHD/19-22

New Proposed Project

Title of the study: **Development of Drought Monitoring System for early warning and preparedness for a selected region in India.**

Project team

Name of PI: **Dr. R.P. Pandey, Scientist G**.

Name of Co-PI: Er. D.S.Rathore, Scientist F
Er. Ravi Galkate, Scientist E
Dr.Sunil Gurrapu, Scientist C,
Ms. Suman Gurjar, Scientist C,

Type of study: Internal project

Total Proposed Project Cost: Rs. 95.0 lakh

Project Duration: 3-years

Date of start: May 01, 2019

Scheduled Date of Completion: March , 2022

Objectives

The main purpose of the proposed project is to develop a scientific tool for regular drought monitoring, early warning and preparedness in drought affected region The specific objectives of the project are as follows:

1. To collect historical information, hydro-meteorological data, crop data, water supply provisions etc.
2. Identification of key hydro-meteorological indicators/indices for monitoring and assessment of drought and severe water scarcity condition.
3. Development of crop map and land use map including demarcation of rainfed and irrigated areas in study region.
4. Development of systematic database setup and computation programs for different drought indices/techniques.
5. Development of composite program and dashboard with menu driven generic system for various drought indicators/indices linked with common data base.
6. Customization of drought monitoring system for district/sub-district level assessment.
7. Evaluation and result verification with field observation.
8. Hosting of the drought monitoring system in NIH web site.

Description of the problem

Drought management including monitoring, early warning, preparedness and mitigations have emerged as priority areas to cope with risk to drought and enhance resilience. Drought as one of a few risks that could lead to high loss and damage in light of the growing number of poor people getting exposed to extreme droughts linked to climate change. Drought preparedness, regional efforts to reduce drought risk, and tools to boost the resilience of people and ecosystems to drought are particularly high on the agenda of many countries in the world.

Monitoring and collecting pertinent weather and climate data is vital to making timely and informed decisions. The Ministry of Agriculture and Formers Welfare (MoAFW), Govt. of India.is nodal agency in India for drought monitoring and Management. The MoAFW has prepared a Manual for Drought Management (MoAFW 2016) incorporating multiple Indices /indicators based on meteorological, agricultural and hydrological variables as follows

Mandatory Indicators		Impact Indicators			
Rainfall Indices		**Agriculture**	**Remote Sensing**	**Soil Moisture**	**Hydrology**
Rainfall Deviation (RFdev) or SPI	**Dry Spell**	**Crop Area Sown**	**VCI or NDVI Deviations**	**PASM / MAI**	**SFI / RSI / SGW**
States may consider any three of the four types of the Impact Indicators (one from each) for assessment of drought.					

The assessment of drought condition using above techniques requires specialized skills. Therefore, development of a regular drought system will be very useful for timely identification of onset of drought, early warning and preparedness.

Proposed Study Area:

It is proposed to take up this study initially for one or two drought affected districts in the Bundelkhand region. Once the system is developed it can be extended to state/region and subsequently entire country may be covered.

. **Proposed Methodology**

The brief methodology of the study will be as follows.

1. Liaising with related departments in the proposed study areas for acquisition of long term hydro-meteorological and other relevant records including climatic data, land use, surface and groundwater and irrigation data.
1. Assessment of existing surface and ground water resources in the study areas.
2. Preparation of GIS maps of drainage, land-use, cropping systems, DEM, water availability including demarcation of rainfed and irrigated areas.
3. Development of an inventory of drought events and their impact and identification of indigenous knowledge (ITKs) on drought mitigation in the study areas.
4. Analysis of meteorological and hydrological data and agricultural records for establishing regional drought indicators/indices, assessment of dry spells and studies of water scarcity regimes.
5. Evaluation of proposed indicators/indices with the past as well as the current information/records and verification of indices and drought assessment criteria.
6. Development of the drought monitoring system and hosting it in the Web-site.
7. Organization of training programs, workshop and demonstrations for capacity building of stakeholders.

Expected outcomes and benefits

The proposed study is envisaged to bring out an improved understanding of drought indicators and the applicability of various indices to monitor drought for early warning and preparedness. An integrated tool consisting of multiple indices will be developed to identify drought conditions in near real time. It will ascertain methods for drought risk assessment and resource assessment for preparedness to cope with drought. The identification of drought hotspots and the classification of land suitability zones will be used to make recommendations with regard to crop types, adjustment of cropping patterns, cultural practices (i.e. adjusting sowing dates to coincide with emerging patterns) and social coping mechanisms and strategies.

Deliverables

The developed tool in the form of software will be hosted in the NIH web site for suitable dissemination of drought related information with selected accessibility to the stakeholders.

Note: A detailed proposal will be placed in table in working group meeting.

WATER RESOURCES SYSTEM DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. Sanjay K Jain	Scientist G & Head
2	Dr. M K Goel	Scientist G
3	Mrs. Deepa Chalisgaonkar	Scientist G
4	Er. D S Rathore	Scientist F
5	Dr. Renoj Thayyen	Scientist E
6	Dr. Manohar Arora	Scientist D
7	Dr. P K Singh	Scientist D
8	Er. Manish Nema	Scientist C
9	Dr. P K Mishra	Scientist C
10	Dr. Vishal Singh	Scientist C
11	Sri P K Agarwal	Scientist B
12	Sri Deepak Singh Bisht	Scientist B

Work Programme for the year 2018-19

SN	Title	Study Team	Duration	Funding (Rs. in Lakhs)
		Ongoing Internal Studies		
1.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S. P. Rai Sanjay K. Jain Sudhir Kumar	3 years (04/14-03/18) Up to 09/2018	
2.	Hydrological process and characterization of Lesser Himalayan Catchments	M. K. Nema Sharad K. Jain Sanjay K. Jain Renoj J.Thayyen P. K. Mishra P. K. Agarwal	5 years (12/14-12/19)	
3	Development of window based software for hydrological data processing and Unit Hydrograph Analysis	D. Chalisgaonkar A. K. Lohani M. K. Goel	1 year (04/18-03/19)	
		Ongoing Sponsored Studies		
1.	Mass and Energy balance of Phuche and Khardung glaciers, Ladakh range	R.J. Thayyen Farooq Azam P.G. Jose A.P. Dimri	3 years (03/16-02/19)	SERB (65.14)
2.	Development of a project website and hydrological database in Upper Ganga Basin **(Sub-project – 1)**	M. K. Goel M. Arora A. K. Lohani D. S. Rathore D. Chalisgaonkar A. R. S. Kumar Surjeet Singh P. Mani A. Sarkar M. K. Nema P. K. Mishra	5 years (01/16-12/20)	DST (52.15)
3.	Real-time snow cover information system for Upper Ganga basin **(Sub-project – 2)**	D. S. Rathore D. Chalisgaonkar V. S. Jeyakanthan L. N. Thakural	5 years (01/16-12/20)	DST (48.83)
4.	Glacial Lakes & Glacial Lake Outburst Flood (GLOF) in Western Himalayan Region **(Sub-project – 3)**	Sanjay K. Jain A. K. Lohani Sudhir Kumar P. Thakur (IIRS)	5 years (01/16-12/20)	DST (36.79)
5.	Assessment of downstream impact of Gangotri glacier system at Dabrani and future runoff variations under climate change scenarios **(Sub-project – 4)**	Renoj J.Thayyen Sanjay K. Jain Sharad K. Jain S. P. Rai P. K. Mishra M. Arora AP Dimri (JNU)	5 years (01/16-12/20)	DST 51.43 (NIH) + 28.29 (JNU)
6.	Observation and modelling of various hydrological processes in a small watershed in Upper Ganga basin	Sharad K. Jain Renoj J.Thayyen Sanjay K. Jain S. P. Rai	5 years (01/16-12/20)	DST (54.07)

	(Sub-project – 5)	Surjeet Sing M. K. Nema P. K. Mishra P. K. Agarwal AP Dimri (JNU)		
7.	Water Census and Hotspot analysis in selected villages in Upper Ganga basin **(Sub-project – 11)**	P. K. Mishra M. K. Nema R. J. Thayyen P. K. Sachan	5 years (01/16-12/20)	DST (90.99)
8.	Dynamics of Himalayan Ecosystem and its impact under changing climate scenario-Western Himalaya	Renoj J.Thayyen P. K. Mishra	3 years (03/17-03/19)	NMHS-MoEF (58.76 lakh)
9.	Measurements and Modeling of Evapotranspiration and other Hydrological Processes in Lesser Himalayas	M K Nema Renoj Thayyen Sharad K. Jain Sanjay K. Jain P. K. Mishra AP Dimri (JNU)	3 years (2016-19)	MOES (Rs. 98 Lakh)
10.	Sustaining Himalayan Water Resources in a Changing Climate (SusHi-Wat)	Sanjay K. Jain (PI) Sharad K. Jain CSP Ojha (PI, IITR)	3 years (2016-2019)	MOES-NERC, Newton-Bhabha project (11.59 Lakh)
11.	Design and development of generic Decision Support System-Hydrology platform for Neeranchal Project	D. S. Rathore Deepa Chalisgaonkar Jyoti Patil	1 year (04/17-03/19)	DoLR (NNWP)
12.	Investigating Water Stress using Hydro-meteorological and Remote Sensing data	D. S. Rathore L. N. Thakural Sanjay Kumar B. Venkatesh M. K. Jose T. Chandramohan	3 years 2017-2020	PDS under NHP
13.	Seasonal Characterization of Gangotri Glacier melt runoff and simulation of streamflow variation under different climate scenarios	M. Arora Sanjay K. Jain	3 years 2018-2021	NIH/ DST
New Internal/ Sponsored Studies				
1.	Developments of Water Accounts for Subarnarekha Basin Using Water Accounting Plus (WA+) Framework	P. K. Singh P. K. Mishra M. K. Goel Suman Gurjar	2 years 2018-2020	
2.	Real time flood modelling using HEC-RTS modelling framework	Vishal Kumar A. K. Lohani Sanjay K. Jain	2 years 2018-2020	

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2019-20/01

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

2. **Project Team:**
   a. Project Investigator: Mr. Manish Kumar Nema, Scientist 'C'
   b. Project Co-Investigators: Dr. Sharad K. Jain, Director,
   Dr. Sanjay K. Jain, Scientist 'G', Head, WRSD
   Dr. Renoj J. Thayyen, Scientist 'E' and
   Dr. P. K. Mishra, Scientist 'C'

3. **Title of the Project:** Hydrological Processes and Characterization of Lesser Himalayan Catchments

4. **Objectives:**
   a. To establish an instrumentation and experimental setup to measure various hydrological and meteorological variables in a watershed in the upper Ganga basin within the state of Uttarakhand for better understanding of their behavior and to study the dynamic linkages between the two.
   b. Analysis and comparison of estimated Evapotranspiration (ET) by different methods like RS/SEBAL, FAO56 method and actual field measurements
   c. To study the various water balance components in the watershed

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

Watershed is supposed to be the basic unit at which the hydrologic processes are studied and is central to most of the concepts in hydrology. Managing agricultural or forested watersheds for water quality and quantity improvement and productivity requires a detailed understanding of functional linkages between eco-hydrological processes and management practices. Various watershed studies are being conducted to understand the fundamental hydrologic and biogeochemical processes and their linkages with soils, vegetation, topography, climate, and management practices worldwide. These studies mainly involve modelling the natural processes but the vibrancy of experimental hydrology broadly across the areas of subsurface and surface hydrology and hydrometeorology still have a unique place of importance and no alternative.

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

6. **Methodology**

(A) Study Area:

A small Himalayan hilly watershed Hinval up to Jijli in the upper Ganga basin in the state of Uttarakhand is proposed for the study. This study area is a paired watershed of two kinds. One of them is a forested catchment (undisturbed) and other one is an agricultural watershed with anthropogenic interventions including an urban habitat at Chamba (Uttarakhand). The geographical extent of the study area is from $30^0 17'$N–$30^0 26'$N latitude and $78^0 16'$E–$78^0 25'$E longitude. This area is a typical representative of a combination of lesser Himalayan hilly temperate climatic conditions with average annual rainfall range of 1200-1800 mm. The Himalayan subtropical forests yield to a belt of temperate broad leaf and mixed forest mainly comprises of pine forest. The total area under study is of 100 km^2 approximately (20 km^2 forested catchment and 80 km^2 the other one) with an elevation range of 999-2676 m. The location map of the watershed and their digital elevation model from SRTM is given in the figure 1.0 for reference. The stream in the forested sub-catchment is the source of drinking water for 87 nearby villages. This stream is being pumped 24x7 by the state authorities at its outlet at Dev Nagar. A study of the topography and land use of the proposed watershed shows that the watershed is representative of the surrounding areas.

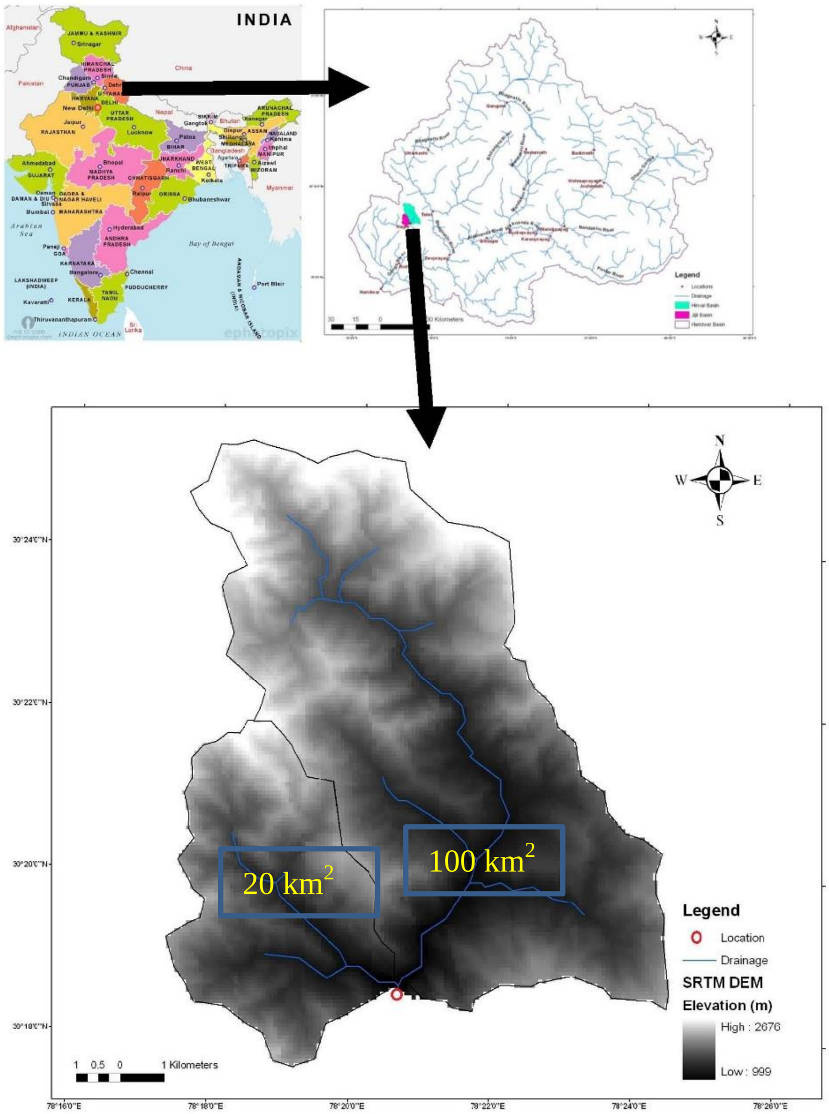


Fig. 1.0 Location of the Hinval watershed up to Jijli within India

(B) Experimental setup

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

(C) Soil Heat Flux

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

(D) Evapotranspiration (ET)

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

(E) Soil Moisture

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

(F) Hydrologic Modelling

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

7. Research Outcome from the project:

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

8. Cost estimates:

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

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

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

9. Quarterly Break up of cost estimate for Year: 2017-18

SN	Sub-head	Amount (in Rupees)			
		AMJ (Q1)	OND (Q2)	JAS (Q3)	JFM (Q4)
1.	Salary	168000.00	168000.00	168000.00	168000.00

2.	Travelling expenditure	50000.00	50000.00	50000.00	50000.00
3.	Infrastructure/Equipme nt	320000.00	320000.00	320000.00	320000.00
4.	Experimental charges	0.00	0.00	0.00	0.00
5.	Misc. expenditure	37500.00	37500.00	37500.00	37500.00
	Sub- Total:	575500.00	575500.00	575500.00	575500.00
	Grand Total:	2302000.00			

10. Work Schedule:

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

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

10. Progress till date:

Majority of the instrumentation towards establishing a classical hydro-meteorological field observatory in the Lesser Himalayan environment has been completed. Few of the data analysis and results pertaining to ET estimation by empirical formulas, SEBAL methods has been presented in the earlier working group meetings. For this working group meeting the development of SWAT model for the study area is being presented. SWAT model for simulating the discharge of Henval at Devnagar gauging site has been setup and preliminary results have been acquired although the model has to be calibrated yet. Since the project is about experimental hydrology, so only once we have some long-term data in hand then some conclusive inferences can be drawn. In between, the project team also has visited the site many a times for various objectives.

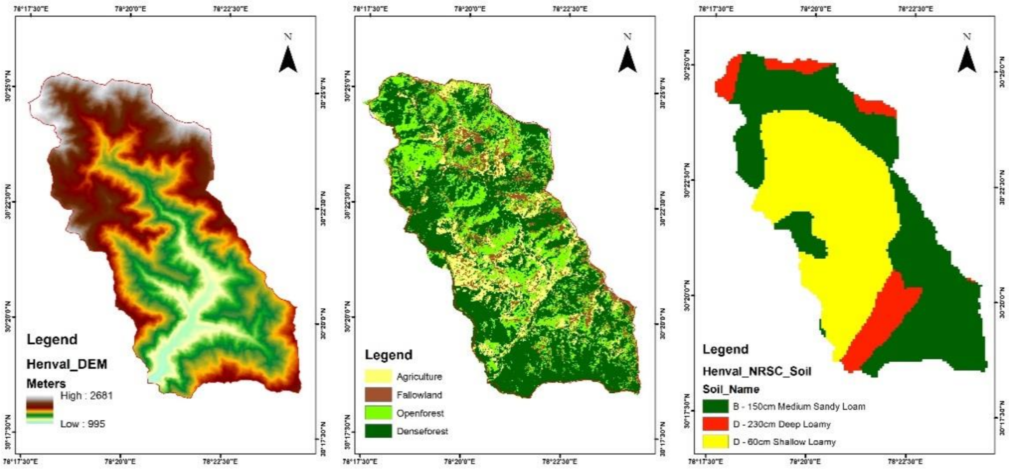


Fig 1. Various Spatial Inputs for SWAT Modeling for Henval Catchment

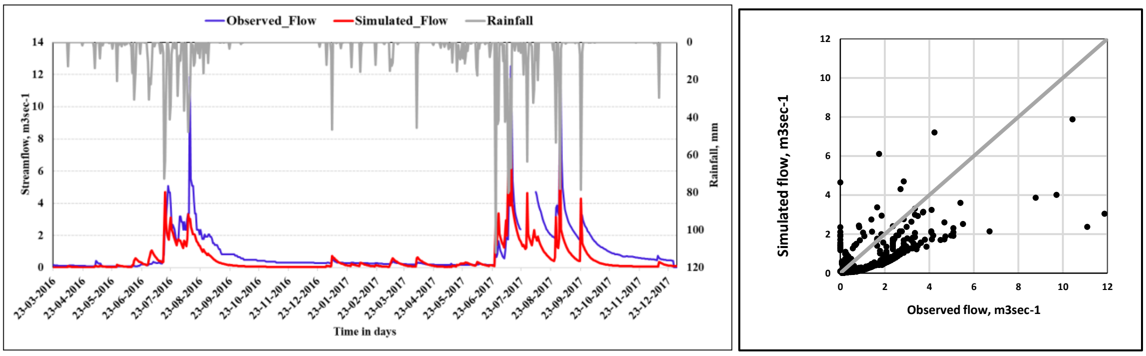


Fig 2. Daily time series plot of observed Vs SWAT-simulated streamflow and rainfall for Henval Catchment

Preliminary SWAT run results indicated that SWAT model is underestimating the flows, this may be due to slow hydrological response of catchment as well as fine tuning or calibration of model and incorporation of catchment specific data such as intensive soil parametrization. These needs to be done in order to achieve better model efficacy

Preliminary analysis of very high frequency data of Eddy Covariance fluxes has also been performed using *Easyflux* software and a python module named *Fluxpart* for carbon-di-oxide and water fluxes. Attempts also had been made to separate the water fluxes into Nonstomatal component (i.e. evaporation) and Stomatal component (i.e. transpiration).

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2019-20/02

1. **Title :** Development of window based software for hydrological data processing and Unit Hydrograph Analysis

2. **Study Group :** Deepa Chaligaonkar, Sc 'G'
   Dr A K Lohani, Sc 'G'
   Dr M K Goel, Sc 'G'

3. **Duration:** April 1, 2018 to March 31, 2019 (One Year)

4. Statement of The Problem:

Unit hydrograph approach is a simple, versatile and popular technique, which is being widely used for the estimation of floods for design of hydraulic structures, drainage system, small bridges, culverts etc. Right from the inception of NIH, a number of softwares/computer program have been developed at NIH for these analyses. However, they were written in FORTRAN/Basica languages which did not provide user-friendly environment to the field users. In view of this, a WINDOWS based software is being developed to carry out hydrological data processing and unit hydrograph analysis for the estimation of flood for gauged as well as ungauged catchments of small and medium size.

5. Methodology:

The software is being developed in VB.NET plateform which supports the development of user friendly environment for carrying out the various computations involved in the hydrological data processing unit hydrograph analysis. The software has following main modules:

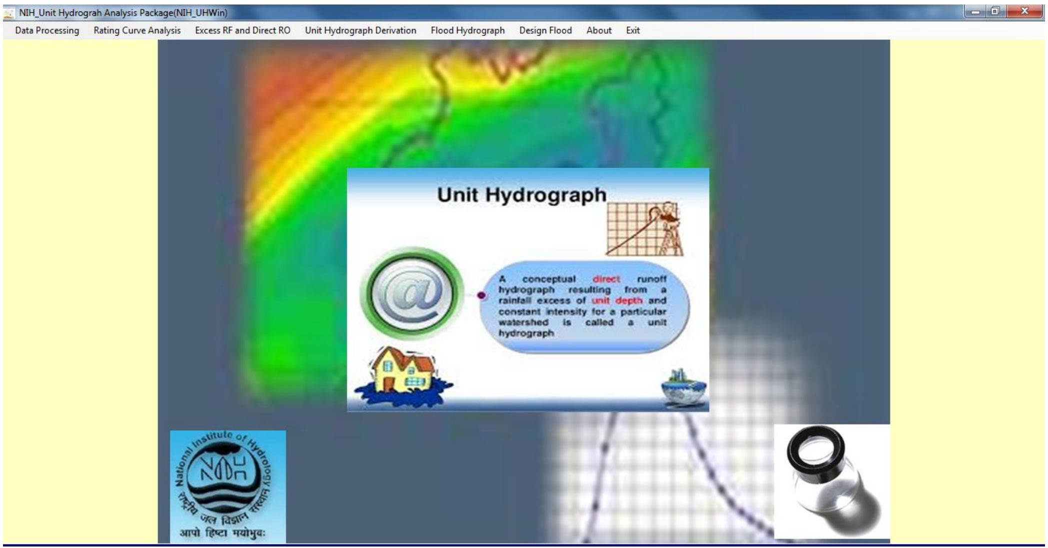
- **Data Processing**
  - Filling up of Missing Data
  - Consistency Check Using Mass Curve,
  - Computation of Areal Average Rainfall,
  - Computation of Variation of Depth with Area
  - Distribution of Daily to Hourly Rainfall
- **Rating Curve Analysis**
  - Discharge from Velocity
  - Development of Rating Curve & Discharge Computation,
  - Discharge from Stages
- **Excess Rainfall (ERH) & Direct Surface Runoff (DRH)**
  - Base flow Separation & Computation of ERH Volume
  - Separation of Base flow using Straight Line Tech.
- **Unit Hydrograph Derivation,**
  - Unit Hydrograph for Gauged Catchments
    a. Collins Method,
    b. Clark Method,
  - Unit Hydrograph for Ungauged Catchments,
  - S Hydrograph Computation,
  - UH of Changed Duration using Superimposition Method,
  - UH of Changed Duration using S-Curve Method,
  - Development of Dimensionless Hydrograph,
  - Development of UH form a Dimensionless Hydrograph

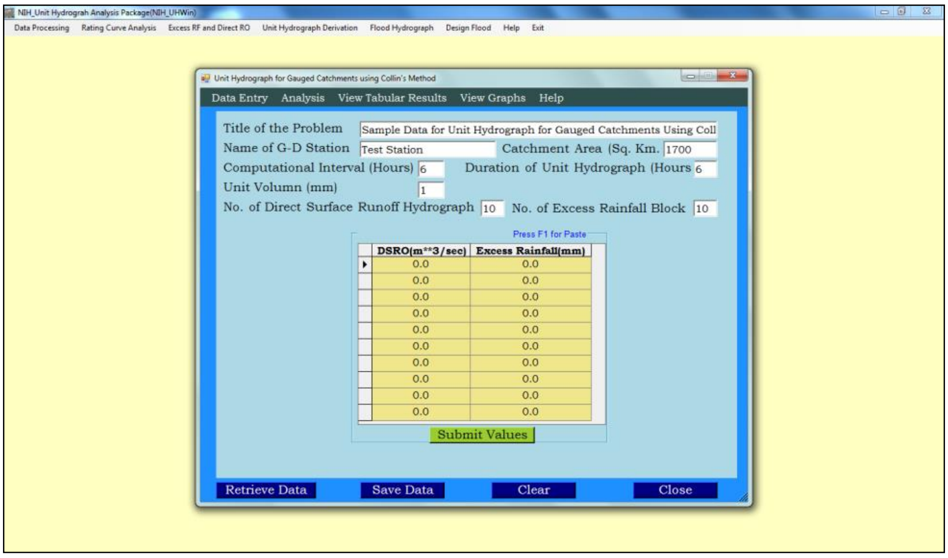
- **Flood Hydrograph**
  - ➢ Computation of Direct Surface Runoff (DRH),
  - ➢ Computation of DRH & Error Functions
- **Design Flood**

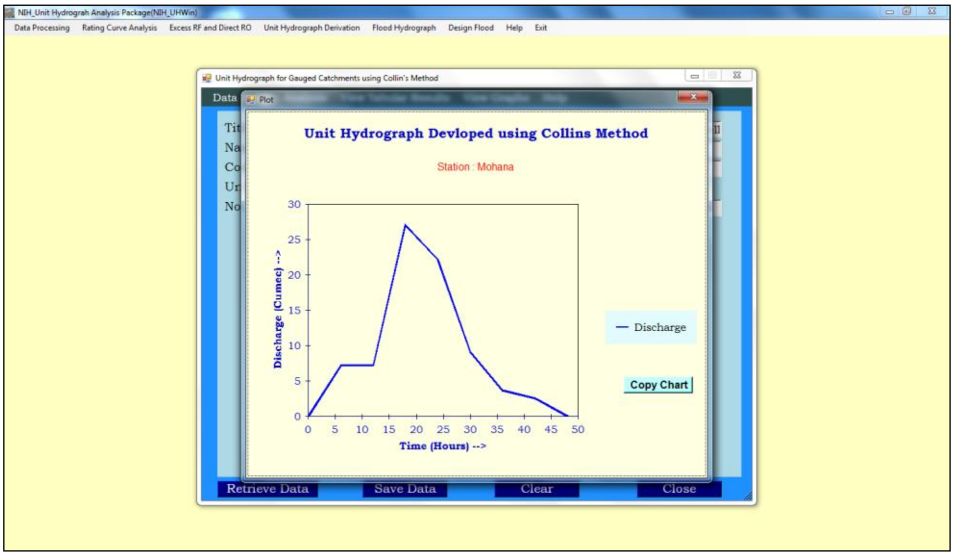
For carrying out these analysis forms have been developed for easy data entry for all the modules. The online help has been provided at each stage of running the package and the results are presented in tabular as well as graphical form.

A setup file will be prepared which will help in easy installation and transfer the software package. When the user will click the setup file, it will automatically create the respective folders, install the software and will create in icon for the software on the desktop. This icon will help in easy execution of the software.

The software is being prepared in vb.net platform. Descriptive data formats have been prepared for easy preparation of data files. Some of the screenshots are shown below:







7. Research Outcome of the Project:

A WINDOWS based Software package for hydrological data processing and Unit Hydrograph analysis is being developed. It is expected that the field engineers will find it useful.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2019-20/03

1. Thrust Area under XII five year Plan
Food security and the sustainable management and use of water resources

2. Project team:

a. Project Investigator:	Dr. P K Singh, Scientist 'D', WRS
b. Co-PI Project Co-Investigator(s):	Dr. P K Mishra, Scientist 'C', WRS
	Dr. M K Goel, Scientist 'G', WRS
	Er. Suman Gurjar, Scientist 'C', GWH

3. Title of the Project– Developments of Water Accounts for Subarnarekha Basin Using Water Accounting Plus (WA+) Framework

4. Objectives-The major objective of this study is to apply newly developed WA+ framework for Subarnarekha river basin in India. The objectives of this study includes assessment of:

1. Agricultural water consumptions using green water and blue water concept
2. Total water withdrawals and their partitioning in to surface and groundwater withdrawls
3. Land productivity and water productivity for food security
4. Consumed and non-consumed water along with beneficial and non-beneficial consumptions
5. Water scarcity and develop water allocation plans from water demand and water supply statistics
6. Available, exploitable, utilized and utilizable water resources

5. Present state-of-art

Water accounting (WA) has emerged in recent years as a key approach to understanding water scarcity and identifying gaps and in-efficiencies in water resources management. Various efforts have been made by United Nations (UN), Food and Agricultural Organisation (FAO), International Water Management Institute (IWMI) and the Australian government to develop standard water accounting (WA) frameworks.

FAO's global information system on water and agriculture (AQUASTAT) is an important source of data, and has the advantage of consistency and standard terminology. However, AQUASTAT falls short of giving enough detail about the interaction between land use and water use. One major point pertinent to water scarce basins is that AQUASTAT focuses on water withdrawals, and does not distinguish between consumptive use and non-consumptive use.

The United Nations Statistics Division has proposed a WA framework called System of Environmental Economic Accounting for Water (SEEA-WATER). However, its applicability for water stock accounting is in question mainly because key required data are unlikely to be available (Perry, 2012). The essential difference in green and blue water resources (Falkenmark and Rockstr¨om, 2006; Rockstr¨om andGordon, 2001) is not recognised in the SEEAW framework.

The Australian Water Accounting Standard (AWAS) developed by the Water Accounting Standards Board (WASB) of the Australian Bureau of Meteorology (BOM) as part of the National Water Initiative (NWI) is based on several aspects of the SEEAW. The framework accounts for water withdrawals rather than consumptive use.The AWAS considers irrigated agriculture, industrial and domestic users and does not provide any information on rainfed systems and natural evapotranspiration (ET) processes.

The International Water Management Institute (IWMI) developed a WA procedure (Molden, 1997) with the aim of tracking water depletion rather than withdrawals to avoid errors when neglecting recycling, and to account for ET. The IWMI WA framework has been applied by IWMI in many irrigation system studies (e.g., Bhakra system inIndia (Molden, 1997); Zhanghe Irrigation System in China (Dong et al., 2004)) and atthe national scale (e.g., India: Amarasinghe et al., 2007; SriLanka: Bastiaanssen and Chandrapala, 2003). However, only a few countries have adopted these WA mechanisms usually due to the lack of data needed to implement these approaches.

6. Methodology

The Water Accounting Plus system (WA+) is based on open access remote sensing data -in conjunction with open access GIS data and hydrological model output. WA+ communicates information on water storage, flows and fluxes for a variety of land use systems using eight intuitive fact sheets, tables and maps that are designed to be understoodby people with technical and non-technical backgrounds alike.

The WA+ framework is developed by IHE-Delft in partnership with IWMI, FAO, and the World Water Assessment Program (WWAP). WA+ is based on a mass water balance approach (at the pixel level) and uses Budyko theory (Budyko, 1974) and WATERPIX model (IHE, 2016) for this purpose. The basis of this water balance approach is that outflow from a certainarea of interest (e.g., river basin) are explicitly related to the net inflow and depletion through a measurable ET processes.

WA+ framework classifies landuse lancover (LULC) in to 80 classes. These 80 LULC classes are further grouped under four main Water Management Classes (WMC), i.e., Protected Land Use (PLU), Utilized Land Use (ULU), Modified Land Use (MLU), and Managed Water Use (MWU). WA+ framework uses the Budyko theory (Budyko, 1974) for measurable ET separation in to ETgreen and ETblue. The Budyko theory is based on the coupling of (a) Water Balance approach and (b) Energy Balance approach. The water balance is performed individually for green and blue pixels, respectively. Following this, WA+ procedure develops eight fact sheets and spatial maps. The eight fact sheets are listed here:

1. Resource Base
2. Evapotranspiration
3. Agricultural Services
4. Utilized Flow
5. Surface Water
6. Groundwater
7. Ecosystem Services
8. Sustainability

In the present study, all the data will be generated for the study basin using open source data. Then WA+ Framework will be applied to achieve the desired objectives.

7. Research outcome from the project

There are eight fact sheets, which will yield many outputs (spatial and temporal estimates) at the pixel level. Estimates of the following will be achieved through this study:

- Exploitable, reserved, utilized, utilizable and non-utilizable flows at river basin scale
- Consumed, non-consumed and recoverable & non-recoverable flows
- Land productivity and water productivity
- Man-made and natural water withdrawls in the basin
- Water supply and demand scenarios and allocation plans
- Surface water availability and surface water storage in the basin
- Groundwater recharge in the basin

8. Work schedule

a. Probable date of commencement of the project:

b. Duration of the project: 02 Years

c. Stages of work and milestone: Shown below

Project Year	**Jan 2019-Dec 2019**				**Jan 2020-Dec 2020**			
Project Quarter	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
f. Data downloading, processing, and generation of data base	↔	↔						
g. Basic data analysis in WA+ framework, Ground truthing surveys for LULC and data collection from CWC, and state govt. departments		↔	↔					
h. WA+ framework application and testing			↔	↔				
i. Calibration and validation of the WA+ framework					↔	↔		
j. Sensitivity analysis of the WA+ models, finalization of results and writing research papers					↔	↔		
k. Final report writing and research paper publications							↔	↔

9. Present progress

Basic Data Preparation:

DEM, Drainage network map, Command area maps, slope & aspect maps, Subernarekha sub-basin maps, soil map, Basin-district intersection maps have been prepared. G&D data of six sites Adityapur, Fekoghat, Ghatsila, Jamshedpur, Jamsholaghat, and Muri have been obtained. Groundwater flux data (1985-2015) has been obtained from CWC, Bhubaneshwar.

Precipitation Data Analysis:

To achieve the objectives of the research project, following analysis have been done for Subernarekha basin. Long-term satellite data of rainfall products (P) of CHIRPS and TRMM was downloaded for the period of 2003-2014 using the WA+ tool box and were analysed to understand the spatial and temporal variability of the rainfall. During the analysis, it was found that year 2013 is wet year and year 2010 was found to be dry year. The raster-to-raster validation of precipitation data product was also conducted during the analysis. The rainfall in the basin is found to gradually increase from upper to lower part with 105 mm/month to 145 mm/month. Monthly precipitation is found to vary from 25 mm to 345 mm/month.

ET data analysis and Water Yield Estimations:

A total of six ET data products, i.e., CMRSET, ETens, GLDAS, GLEAM, SEBS and SSEBop were also downloaded using WA+ tool box and raster-to—raster validation was performed. Temporal and spatial variability of ET was analysed for Subernarekha basin. Monthly average ET is found to vary from 45 mm/month to 110 mm/month. Seasonal and inter-annual variability of CHIRPS, TRMM, and ET and Water Yield (P-ET) was also analysed for the basin. The Water Yield was found to be higher for the wet year. i.e., 2013 and lowest for the dry year, i.e., 2010. On seasonal scale, the water yield was found to be negative for JAN-MAY and NOV-DEC, with the highest value of 235 mm/month in the month of August.

WALU Map and Sheet 2 Development and Analysis:

The LULC map was prepared using open source data sets as per WA+ frame work (named as WALU) for the Subernarekha basin. The open source data for WALU consisted of MODIS, GLOBCOVER, MIRCA, WDPA, data on Lakes, rivers and reservoirs, and IWMI irrigated areas map along with NRSC LULC map. WA+ framework consists of 80 types of land use classes. WALU map along with ET, Leaf Area Index (LAI), net primary production (NPP), gross primary production (GPP), daily precipitation maps were used for generation of Sheet 2. The Sheet 2 (Evapotranspiration sheet) gives information about the beneficial and non-beneficial ET and ET as per land use. The ET was also further separated into evaporation (E), transpiration (T) and interception (I) based on WALU for Subernarekha basin.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2019-20/04

1. Thrust Area under XII five-year Plan

Flood modeling and inundation mapping

2. Project team:
Dr. Vishal Singh, Scientist C
Dr. A K Lohani, Scientist G
Dr. Sanjay K Jain, Scientist G

3. Title of the Project -

Real time flood modelling in Southern River basin using HEC-RTS modelling framework.

4. Objectives-

The present study was taken to explore the flood discharge and their inundation in the Southern river basin. During extreme high rainfall events, the frequency of flood events increases. The high amount of flood discharge may cause severe flood conditions in the downstream portion of the river basin. A destructive flood hazard has been recently happened in the Kerala state of India (2018) during monsoon season. Therefore, the purpose of this research work is to provide the advance research and engineering guidelines as per the adopted approaches and methodologies for the hydrological and hydrodynamic assessment of the flood discharge and inundation in the Southern river basin under extreme scenarios. Following are the objectives:

1) To process and accuracy assessment of the rainfall dataset over the selected river basin by utilizing satellite-based rainfalls (e.g. TRMM+GPM) and measured rainfalls (e.g. IMD gridded rainfalls).
2) Construction of the hydrological model (i.e. HEC-HMS) to generate stream flows at different sections of the river channels.
3) Climate change assessment on Periyar river flood flows utilizing GCMs/RCMs and Statistically downscaled multi-model CMIP5 GCMs datasets.
4) Generation of flood discharges at different sections of rivers and the development of flood inundation maps in a stochastic manner including multiple return periods (e.g. 20 year, 50 year, 100 year, 500 year and 1000 year).
5) Construction of the 2D Flood model by the coupling of hydrological model (i.e. HEC-
6) HMS) and hydrodynamic model (i.e. HEC-RTS) named as HEC-RTS framework.

5. Study Area –

For the present research work, the Periyar river basin has been selected as shown in Figure 1.

6. Methodology

6.1 Dataset

For the proposed study, the real time time-series rainfall datasets with high spatial resolution along with other meteorological variables (e.g. temperature, humidity, radiation, wind etc.) will be utilized from different sources such as Indian Meteorological Department Rainfalls, APHRODITE rainfalls, TRMM rainfalls etc. Similarly, other meteorological variables will also be acquired from these organizations. The high resolution digital elevation model (DEM) and other thematic layers such as landuse/landcover (LULC), Soil map will also be utilized. The hydrodynamic parameter/datasets will be collected from the nodal agencies and on the field as per their requirements. The overall methodology (Figure 2) has been classified into three components as given below:

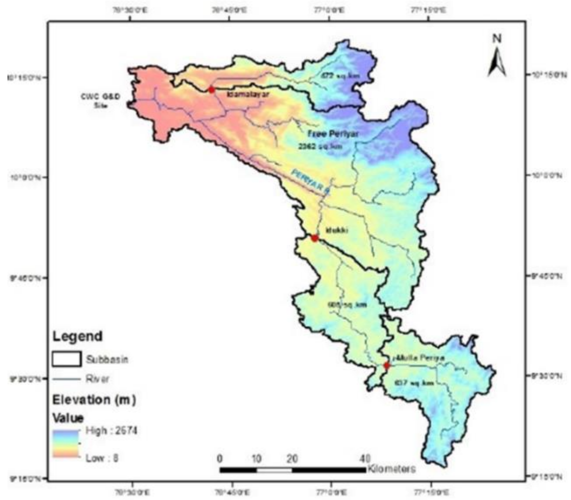


Figure 1: Periyar river basin highlighting the locations of targeted reservoirs (in red circle point).

7. Progress & Research Outcomes

7.1 Rainfall data assimilation and bias correction

The HMS and HEC-RAS model have been proposed to run at 3 hourly time intervals to create the historical Kerala flood event (2018). Therefore, in the absence of hourly IMD rainfalls, the TRMM+GPM satellite-based rainfalls data were downloaded at 3 hourly intervals. Then we aggregate the 3-hourly rainfalls to daily rainfalls for the bias correction with reference to IMD daily rainfalls. Based on the ratio of three hourly TRMM-GPM rainfalls the daily bias computed with reference to the IMD rainfalls has been adjusted and finally the TRMM corrected rainfalls were generated to setup HMS and RAS model. The results are shown in Figure 3.

7.2 Computation of HEC-HMS hydrological parameters

Based on the available datasets, the HEC-HMS model variables and parameters have been computed. For hydrological modeling using HEC-HMS, the basic inputs such as base flow, modified curve numbers (CNs), LULC map, soil map, lag time and other calibration parameters required to setup model have been computed using various mathematical governing equations. For baseflow the, recession method has been applied. CNs are modified and updated as per the catchments characteristics utilizing hydrological response units (HRUs) computed based on LULC, soil and slope. In HMS, the basin lag is a crucial parameter and SCS unit hydrograph method has been used.

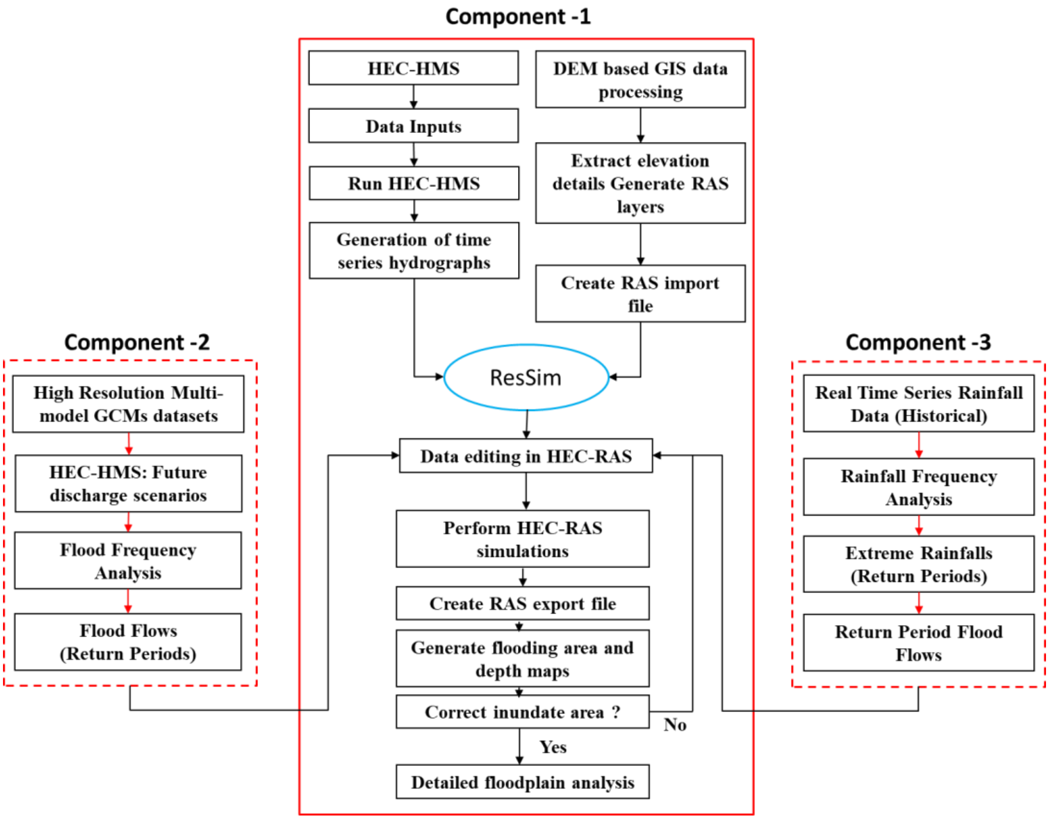


Figure 2: Proposed methodology chart.

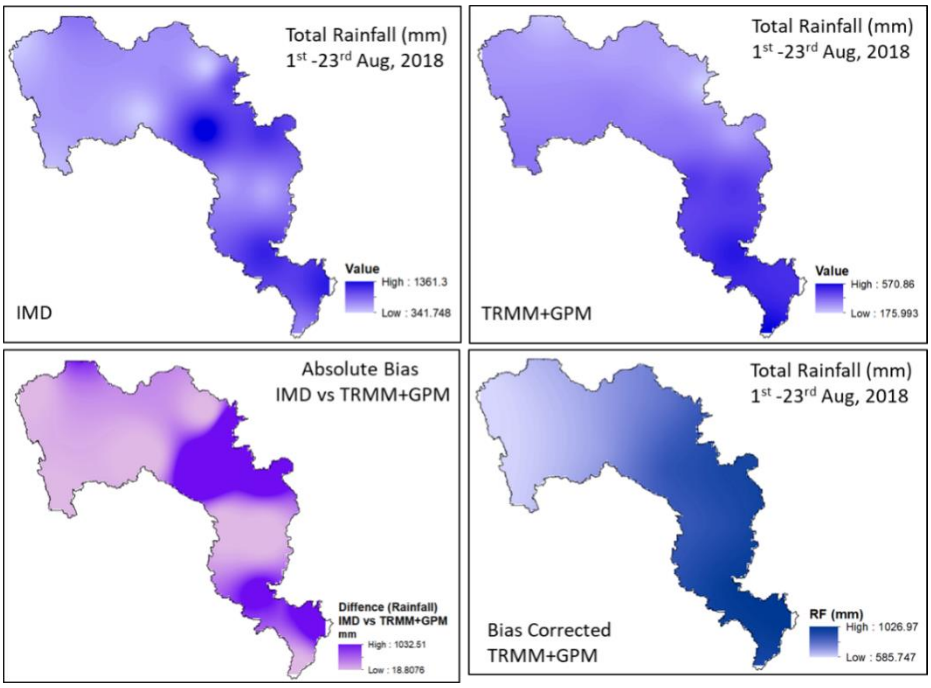


Figure 3: Bias correction of TRMM+GPM based hourly rainfalls with reference to IMD rainfalls.

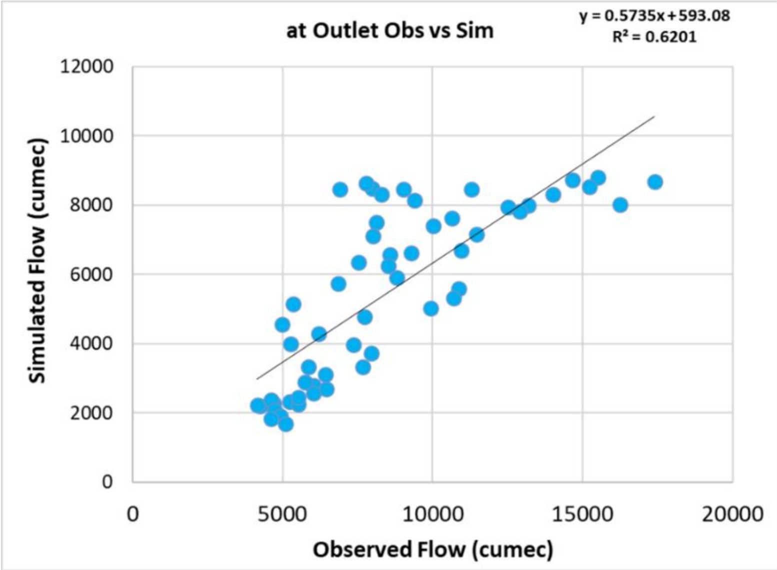
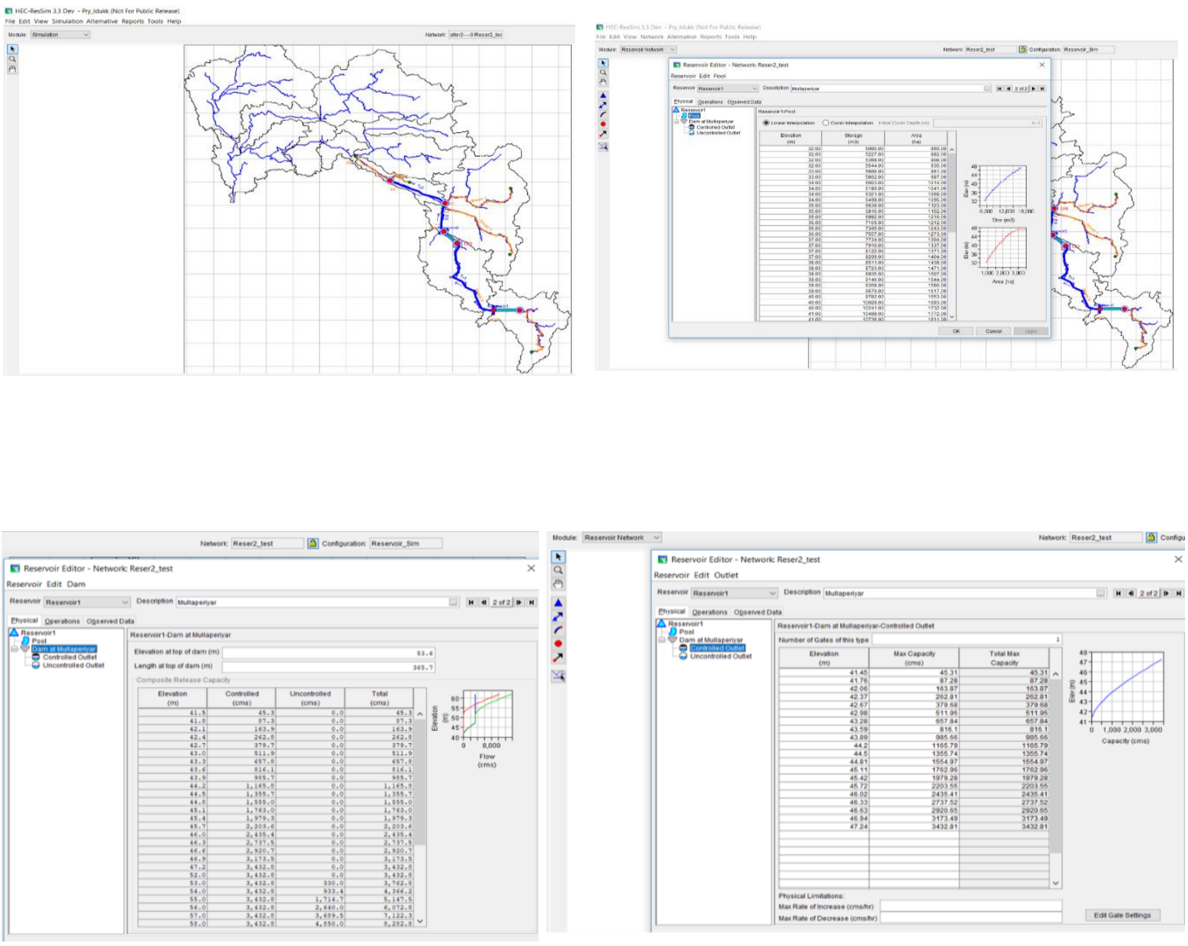
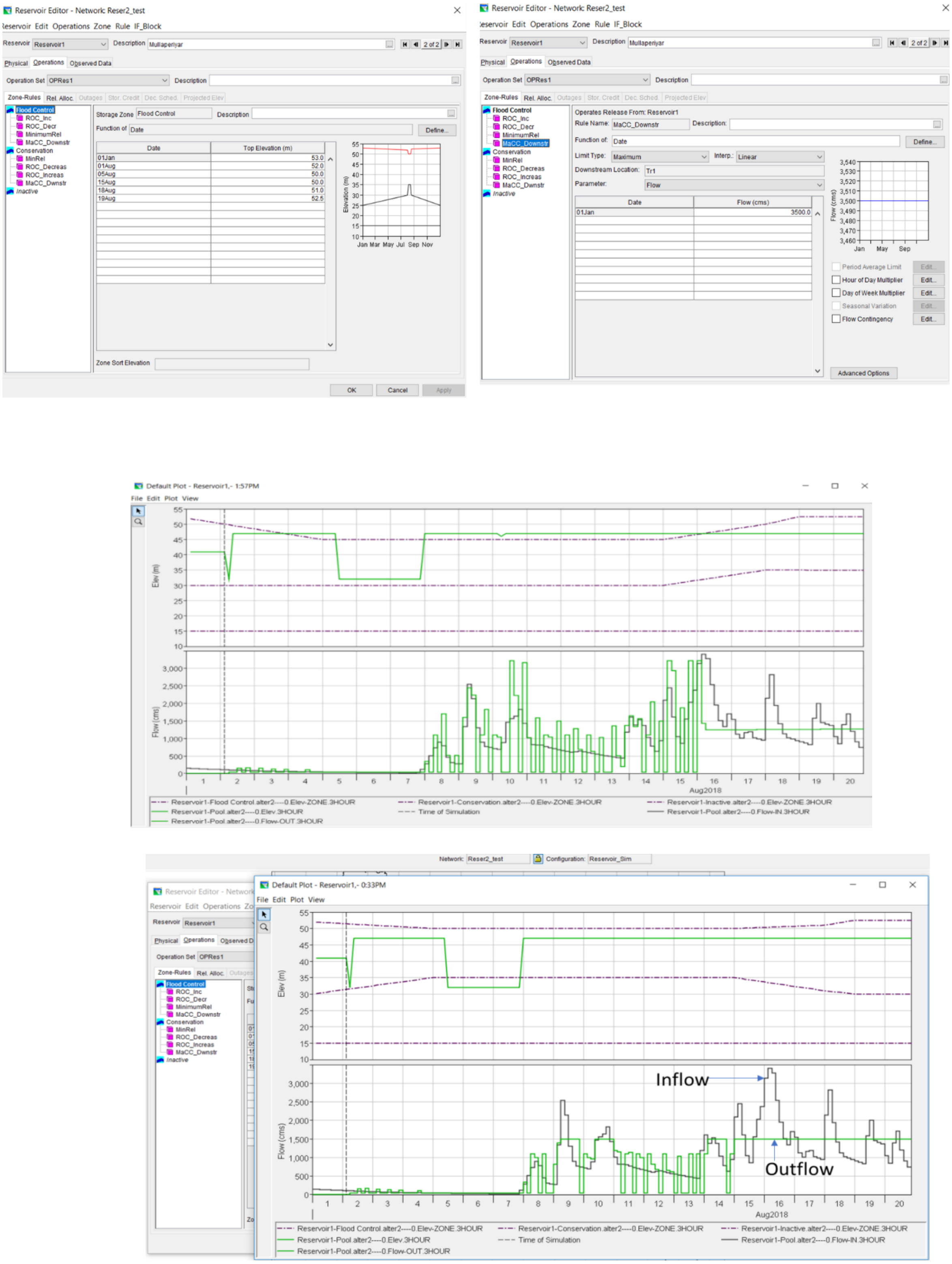


Figure 4: Comparison of calibrated discharge versus observed discharge at Neeleswaram gauge.

7.4 Reservoir Optimization through HMS and HEC-RESSIM

The reservoir simulation has been in progress (Figure 5). The reservoir parameters are computed from empirical equations and several datasets are collected from Central Water Commission and published report. The Mullaperiyar dam situated at the upstream portion of the Periyar river and Idukki and Idamalayar dams are situated in the downstream portion. Initially, the reservoir operation rules are constructed for the Mullaperiyar dam and regulated flow has been simulated and the flood peaks are significantly minimized.





Figures 5: Reservoir operation setup and simulation using HEC-RESSIM at Mullaperiyar dam.

7.5 Climate change assessment

For the climate change assessment using GCMs/RCMs data on future flood impacts on Periyar river basin, the dataset has been downloaded. Initially, the applicability and correctness of GCMs/RCMs have been validated by the comparison of GCMs/RCMs/Statistical downscaled multi-model datasets. The uncertainty evaluation of GCMs/RCMs are done to avoid further uncertainty in the GCMs/RCMs based simulated streamflow scenarios. Finally, the less uncertain GCMs/RCMs based temperature and precipitation datasets will be utilized to generate flood flows and return period maps. The main purpose of this detail uncertainty analysis is to enhance the accuracy in projected streamflow and return period-based flood flows.

8. Work to be done

1 – Reservoir simulation for Idamalayar, Idukki and Mullaperiyar dams

2 – Rule curves and optimization of all reservoirs for historical flood event (2018).

3 – Simulation of final flows for the historical event (2018) at each catchment using HMS incorporating reservoir parameters and elevation-area-storage-discharge function.

4 – Simulation of GCMs/RCMs based flood flows

5 - RAS model setup and generation of flood flows

6 – Flood frequency analysis and computation of different return period flood maps.

7 – The real time data for reservoir operation (e.g. elevation-area-storage-discharge) is still not available.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/01

1. **Thrust Area under XII five Year Plan**: Himalayan Cryosphere and Climate Change
2. **Project Team:**

   Project Investigator **:** Dr. R.J. Thayyen, Sci-E
   Project Co-Investigators : Dr. Farooq Azam, Inspire Faculty-NIH (Now IIT Indore)
   Dr. P.G. Jose, Sci-D, WHRC, Jammu
   Prof. A.P. Dimri, SES, JNU

3. **Title of the Project:** Mass and Energy balance of Phuche and Khardung glaciers, Ladakh range
4. **Objectives:**
   1. Winter and Summer Mass Balance studies of Phuche and Khardung glaciers for building a long term mass balance data series.
   2. Energy balance studies for understanding the reasons of contrasting mass balance response of Phuche and Khardung glaciers.
   3. Improving regional climate downscaling for Ladakh region using ground observations and study of glacier–climate linkages.

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

Headwater runoff is sustaining life and livelihood in the cold-arid regions of Ladakh. Due to this reason mass balance response of the small glaciers in the Ladakh range raises considerable interest. Lack of mass balance studies across diverse glacio-hydrological regimes of the Himalaya limited our understanding of climate – glacier linkages across the Himalayan region. Considering these aspects, a long-term mass balance research programme was funded by SERB on Phuche glacier in the year 2010. Since then winter and summer mass balance data is being generated over the Phuche glacier. 5 years of mass balance studies have shown that the Phuche glacier have cumulatively lost about 900 mm w.e. during these period. A nearby glacier named Khardung glacier is also studied additionally for winter and summer balance during these period. This glacier is part of the six glaciers of Khardung glacier complex and separated from Phuche glacier by around 2.5 km. Both these glaciers have NE aspect and under similar climatological setup. Khardung glacier is in the Nubra side of the Ladakh range while Phuche glacier feed into River Indus. Even though these glaciers are under seemingly experiencing similar weather, mass balance study of Khardung glacier showed enormous mass loss of this glacier with a cumulative loss up to 2300mm w.e during these five years. Reasons for such a contrasting mass balance response need thorough investigation. All the instrumentation in the region is focused on the Phuche glacier catchment and prevailing weather condition or energy balance of Khardung glacier is unknown. Present project is formulated to undertake detailed study of these two glaciers to understand the contrasting mass balance behavior.

6. **Methodology**

   1. Mass balance studies will be carried out by glaciological method including winter and summer balance with an aim to build up long-term mass balance series.
   2. Monitoring of climate parameters of AWS installed at Phuche glacier near ELA (5600 m a.m.l). The energy balance study was carried out of the Phuche glacier.
   3. Regional climate downscaling and parameterization

Use of regional climate model (RCM) outputs "without tuning" to evaluate hydrological and glacier responses to climate change in the Himalayan high mountains is still elusive (Yasunari et al., 2012). And thus it is imperative to assess the sensitivity of RCMs for hydrological and glaciological studies at basin level. Also, during winter, having an understanding of the liquid–solid precipitation ratio within the model framework is important for various hydrological and glaciological purposes. In present project statistical downscaling approach modifying dynamically downscaled outputs using Statistical Downscaling and Bias Correction (SDBC) method will be employed.

7. Research Outcome from the project:

Winter and summer mass balance of two glaciers, SEB data on two glaciers. Research papers with better understanding of climate forcing and factors controlling the glacier mass balance in the cold-arid system.

8. Cost Estimate : 65.14 lacs

Total cost of the project: Rs. 65.14 lakhs
b. Source of funding: SERB-DST

9. Work schedule

k	Year 1				Year 2				Year 3			
Acquisition of Equipment & logistics material												
Appointment of project staff												
Mass balance measurements												
Meteorological monitoring by three existing AWS												
SEB monitoring												
Data Interpretation &Analysis												
Report writing												

10. Analysis and results

The mass balance data of Phuche and Khardung glaciers generated during the 2018 summer ablation period is processed for estimating the glacier mass balance for the year 2017-18. 2018 was negative mass balance year for both the glaciers. The winter mass balance for the year 2017-18, as measured in the month of May 2018 was very low at 0.27m we. For Phuche glacier and 0.266 m w.e. for Khardung glacier. The annual mass balance for the year 2017-18 was -0.81 m w.e. for Phuche glacier and-1.84 m w.e. for Khardung glacier. During the period both the glaciers experienced negative mass balance across the glacier with no accumulation. The 10 m long glacier ice temperature profler data of Khardung glacier installed in September 2017 has retrieved in September 2018 and found that the Khardung glacier is a cold glacier. This is the first glacier identified as cold-glacier in the IHR region. Automatic weather station installed over the Khardung glacier encountered some glitches during the winter period with very cold- temperatures up to -28^{o}C. The instrument is attended in June good data on SEB is generated for core ablation months. Analysis of this data is in progress.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/02
NMSHE STUDIES

1. Title - Development of a project website and hydrological database in Upper Ganga basin

2. Study team

1. Dr. M. K. Goel, Scientist 'G', NIH, Roorkee - PI
2. Dr. M. Arora, Scientist 'D', NIH, Roorkee – Co-PI
3. Dr. A. K. Lohani, Scientist 'G', NIH, Roorkee
4. Mr. D. S. Rathore, Scientist 'F', NIH, Roorkee
5. Mrs. D. Chalisgaonkar, Scientist 'G', NIH, Roorkee
6. Dr. A. R. S. Kumar, Scientist 'F', NIH, Roorkee
7. Dr. Surjeet Singh, Scientist 'E', NIH, Roorkee
8. Mr. P. Mani, Scientist 'D', NIH, CFMS, Patna
9. Dr. A. Sarkar, Scientist 'D', NIH, Roorkee
10. Mr. M. K. Nema, Scientist 'C', NIH, Roorkee
11. Smt. Suman Gurjar, Scientist 'C', NIH, Roorkee
12. Dr. P. K. Mishra, Scientist 'C', NIH, Roorkee

3. Objectives

The objectives of the project are:

a) Development of a coherent hydrological and hydro-meteorological database in Upper Ganga basin.
b) Processing and analysis of hydro-meteorological data in study area.
c) Assessment of adequacy of hydro-meteorological network in study area.
d) Investigation and referencing of available spatial database from various sources for use in water resources management.
e) Capacity building for use of hydrological data entry and processing software for maintaining hydrological database.
f) Development of interactive project web site for NIH projects under NMSHE including a web-based hydrological information system.

4. Sponsored by DST, New Delhi

5. Project Cost Rs.113.22 Lakh

6. Brief Background

The first important task in hydrological analysis for a river basin is the collection of true, accurate and regular hydrological and hydro-meteorological data. In our country, a number of organizations are involved in collection of hydrologic and meteorological data. However, it is also important to integrate the data related to different hydrological variables (say, rainfall, snowfall, temperature, humidity, wind speed, sunshine, river flow, groundwater observations etc.) in a database so that comprehensive analysis and processing of hydrologic variables in a river basin can be made. In addition to the point observations, a number of satellite platforms (such as Resourcesat, Cartosat, MODIS, TRMM, APHRODITE etc.) are now providing spatial information in various observation windows (or bands), some of which are on-line in public domain. This information can be referenced at a single platform for use in hydrological analysis for various purposes.

Data collected on hydrologic variables are generally raw which may not be used directly in most hydrologic analysis work. Processing of hydrological data has two major objectives: one to evaluate the data for its accuracy and the other to prepare the data in a form valuable to the users. The rapid advance in computer technology, in speed of operation and data storage capacity as well as the capability of hydrological software has greatly simplified the management of large quantities of hydrological data. All hydrological datasets can be maintained in well-defined computerized databases using standard database management system. Surface Water Data Entry System (SWDES), developed under Hydrology Project – I, and HYMOS software can be used for entry and processing of hydrological data in standardized format. This is essential for the long-term sustainability of the datasets in proper form and their dissemination to the end users. Both, raw and processed data sets are to be properly stored and archived to specified standards so that there is no loss of information. NIH has trained manpower on SWDES and HYMOS software which can be used entry and process the hydrological database for the Upper Ganga basin up to Rishikesh and to build capacity in other organizations dealing with hydrological data for their effective utilization.

For mountainous areas, significant variation in altitude, slope, aspect, soil, and land use characteristics over short distances requires high density of hydrometric networks for reliable assessment of hydrological variables. However, due to various operational problems such as approachability, low temperatures, snowfall, high velocity flows with boulders and sediments etc., hydro-meteorological information available in the mountainous regions is quite limited due to lack of proper observation network. There is an urgent need to properly design and upgrade automated hydro-meteorological networks suitable for the prevailing climate in the region for long-term monitoring and database development. It is envisaged to analyze the existing hydro-meteorological network in the study area and analyze its adequacy using different techniques.

There has been widespread concern over the global change in climate and its impact on various hydrological variables. This impact is not uniform globally and mountainous regions are considered to be more susceptible to climate change. It is envisaged to carry out trend analysis of long-term data of hydrological variables to assess the possible impact of climate change on various hydrological processes. These findings can be used to analyze various scenarios of water availability and demand to develop strategies for proper management of water resources in future. Finally, it is envisaged to develop the web-site of the project for online information about various studies and sub-projects being carried out and the intermediate dissemination of results. It is also planned to link the web-based hydrological information system with the site to show the summary/gist of processed data at various observation sites in the study area.

Present Progress

All the hydro-meteorological data (IMD and CWC) for various stations in/around the Upper Ganga basin has been imported in SWDES and HYMOS data processing systems. The basic statistics of different stations has been worked out. The spatial correlation among rainfall stations has been developed and stations within close vicinity and with good correlation have been identified for gap-filling of the missing data and for development of double-mass curves. After analysis and correction of data with double mass curve, the trend analysis is planned to be carried out for different stations. The development of GIS maps for most of the planned attributes has been completed.

Project website has been significantly enhanced. Content development of website like write-ups of about Himalayas, NPCC/NMSHE, Upper Ganga basin has been completed. Some features like sub–project details and their progress is updated on respective webpages. Metadata of daily rainfall, temperature and meteorological data with their respective station maps from IMD and CWC has been uploaded in website. In addition, for CWC stations, metadata of discharge, water level, temperature, sediment flow, water quality and cross-section data with station maps has been updated. Some other improvements (say, pop-up of basic statistics of station data on being clicked in GIS domain) are currently being incorporated. In addition, relevant reviews and publications in the study domain are under continuous updation.

Figure – 1: A screenshot of the NMSHE website

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/03
NMSHE STUDIES

1. Title - Real-time snow cover information system for Upper Ganga basin

2. Study team

a) Project Investigator:	D. S. Rathore, Sc. "F"
b) Project Co- investigators:	Deepa Chalisgaonkar, Sc. "G"
	V.S. Jeyakanthan, Sc. "E"
	L.N. Thakural, Sc. "C"
c) Project Staff (JRF)	Asish Bhandari, JRF
	Shravani Singha, JRF

3. Objectives

The objectives of the project are:

a) Development of methodology for snow cover delineation in study basin using multispectral remotely sensed data.

b) Development of web-GIS application for real-time snow cover information in study basin.

4. Sponsored by DST, New Delhi

5. Project Cost Rs.77.992 Lakh

***Date of commencement of project*:** January, 2016

***Duration of the project*:** 5 years

6. Statement of Problem

To study long-term snow cover extent variations, long-term and high temporal resolution snow cover maps are needed. MODIS data repository spans over nearly 17 years and highly suitable for hydrological studies. However, high temporal resolution data have coarser spatial resolution and introduces error due to mixed pixels. The data may be compared to better spatial resolution satellite data to assess its accuracy. The information generated may be further disseminated to stakeholders through web technology.

7. Present state-of-art

MODIS snow products, namely snow extent, snow fraction and grain size are available in public domain. Snow grain size has been utilized in modifying cloud mask and thus in post processing of the snow extent. Post processing algorithms also utilize filters and altitude masks. An web application developed by ICIMOD disseminates monthly snow statistics for basins in Hindu- Kush Himalaya.

8. Methodology

Satellite remote sensing imagery will be used for the extraction of snow extent and snow cover. Various techniques e.g. NDVI-NDSI regions for snow underneath forests, comparing multi spatial-resolution images for fraction snow cover determination etc. will be employed. Snow extent and its statistics will be published using Web GIS software such as Geoserver, Open layers, GeoExt etc. In addition, the available web services of spatial data e.g. Open Street Maps, Google maps etc. will also be utilized.

9. Location map/ study area

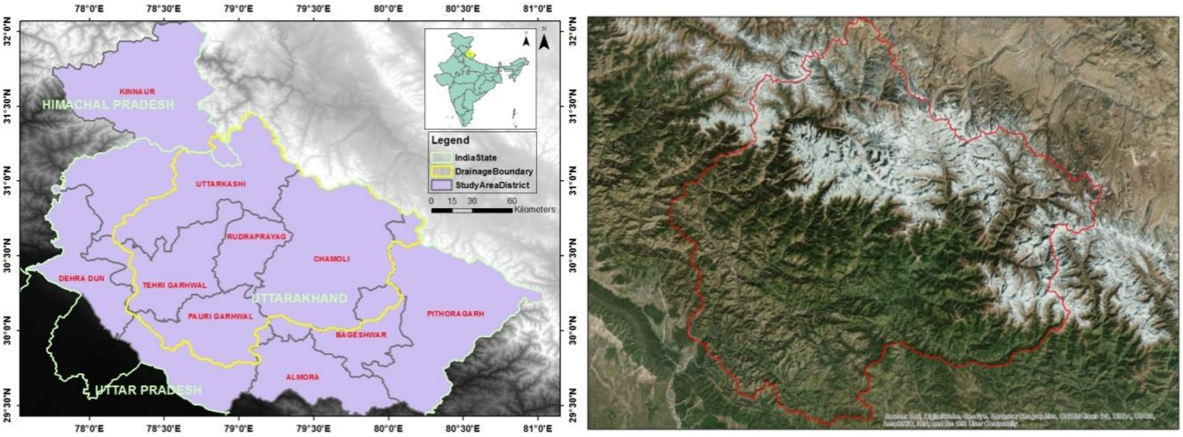


Fig. 1: Upper Ganga basin up to Trivenighat (Left), Satellite imagery for the basin (Right).

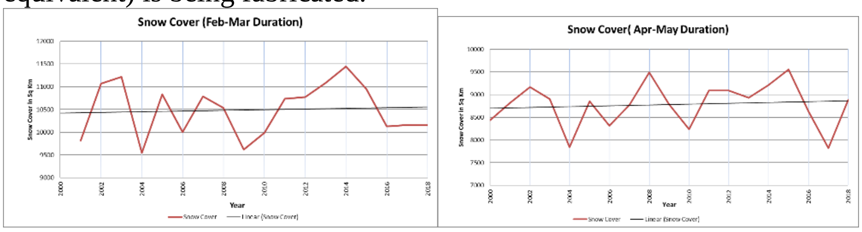
9. Approved action plan and time line

Activity	1st year		2nd year		3rd year		4th year		5th year	
	I	II	I	II	I	II	I	II	I	II
Processing of satellite data and GIS layers for delineation of snow	←	—	—	—	—	—	—	—	—	→
Development of web GIS application for snow	←	—	—	—	—	—	—	—	—	→
Field visit for ground truth and observations	←	—	—	—	—	—	—	—	—	→
Preparation of interim/ final reports		↔		↔		↔		↔		↔

10. Recommendations/ suggestions in previous WG

None.

11. Achievements

Year	Objectives	Achievements
2018-19	Snow extent methodology	In MODIS semi- automatic post processing procedure implemented in R, temporal filter was added. NSIDC MODIS Snow extent maps (version 6) data were post processed (altitude-based mask and temporal filter) for Upper Ganga basins. (Fig. 3). Yearly median snow extent in Upper Ganga basin for February- March and April- May derived from gap filled post processed NSIDC eight-day MODIS snow extent data indicate increasing trend (not significant at 95% significance level). Visit was made to Uttarkashi for locating SOI GPS station at Bhela Tipri near Bhatawari during November 28- 30, 2018. Snow sampler (similar in design to Federal Snow sampler used for determining snow water equivalent) is being fabricated.  Fig. 2 a,b Median snow cover for Feb- March and April- May

2018-19	Web GIS application	The web GIS application developed for maximum, minimum and monthly snow extent was updated from NSIDC MOD10A2 version 5 to version 6 data product.

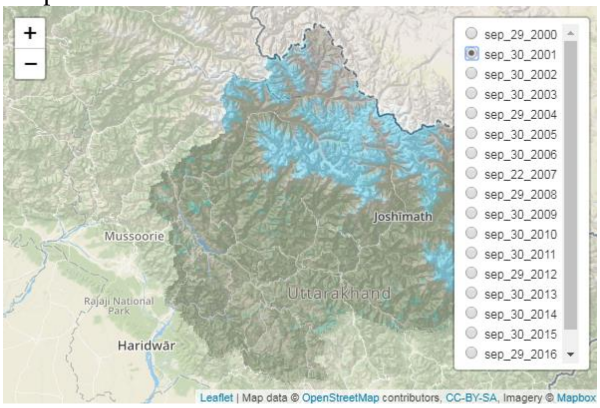


Fig. 3 Web GIS application for minimum snow extent

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/04
NMSHE STUDIES

1. Title - Glacial Lakes and Glacial Lake Outburst Flood (GLOF) in Western Himalayan region

2. Study team

1. Dr. Sanjay K. Jain, Scientist 'G', NIH, Roorkee - PI
2. Dr. A. K. Lohani, Scientist 'G', NIH, Roorkee – Co-PI
3. Dr. Sudhir Kumar, Scientist 'G', NIH, Roorkee
4. Dr. P. Thakur, Scientist 'D', IIRS, Dehradun

Project Staff (JRF) Mr. Amit Shukla, JRF

3. Objectives

The objectives of the project are:

1. To generate data base with regard to glaciers and glacial lakes in basins located in Western Himalayan region.
2. To define conditions of glacial lakes, moraine dams associated with mother glaciers attributing those with topographic features around lakes/moraine dams.
3. Analysis of the data to identify the potentially dangerous and vulnerable glacial lakes susceptible to outburst.
4. To define geometrical parameters (spread area, depth and volume of water etc.) of the vulnerable lakes and their further examination.
5. GLOF modeling using the hydro-dynamic mathematical modeling.
6. To disseminate the results and outputs among relevant oragnisations in the region that could make use of this information for GLOF hazard prevention and mitigation planning.

4. Sponsored by DST, New Delhi

5. Project Cost Rs. 41.796 Lakh

6. Brief Background

The climatic change/variability in recent decades has made considerable impacts on the glacier lifecycle in the Himalayan region. Warmer climates of the past have resulted in glacier retreat and the formation of glacial lakes in many mountain ranges. As the glaciers area retreating, some glacial lakes are formed behind the new exposed terminal moranins. Rapid accumulation of water in those lakes particularly in those adjacent to receding glaciers, can lead to a sudden breaching of the unstable dam behind which they have formed. The sudden discharge of large volumes of water with debris from these lakes potentially causes Glacial Lake Outburst Floods (GLOFs) in valleys downstream.

In order to assess the possible hazards from such lakes it is therefore essential to have a systematic inventory of all such lakes formed at the high altitudes. To identify the individual glaciers and glacial lakes, different image enhancement techniques are useful. Besides making a temporal inventory, a regular monitoring of these lakes is also required to assess the change in their nature and aerial extent. The criteria for identifying potentially dangerous glacial lakes are based on field observations, processes and records of past events, geo-morphological and geo-technical characteristics of the lake and surroundings, and other physical conditions. Once the vulnerable lake is identified, Mathematical modeling of dam breach floods can be carried out by either one dimensional analysis or two dimensional analyses.

7. Methodology

The studies for outlined focused area would involve following work items:

(i) Collation of literature & reference documents, procurement Remote Sensing Data from appropriate agencies-national and though on line sources.

(ii) Formulation of data on Glacial Inventory of the Basins defining snow line, different glaciers, their attributes and classification.

(iii) Establishing Glacial Lake and Moraine Dam Inventory in the Basins and defining geometric parameters of lakes, possibility of their inter-connectivity, and geomorphic classification to work out their vulnerability status.

(iv) Analysis of Glacial Lake database to identify the vulnerable lakes and their possibility of out burst under different causative modes. Defining breach parameters to estimate the scale of hazard on incidence of the GLOF.

(v) Defining slope attributes of the river from vulnerable lake/lakes to project sites and cross sections of the river-valley which would carry the flood on incidence of GLOF; the parameters would be defined based on remote sensing data.

(vi) Hydrological studies on GLOF/ Moraine Dam Break Simulation and consequent lake breach flood using the hydro-dynamic mathematical modeling.

(vii) Recommendation for the establishment of a system for monitoring potential risk lakes.

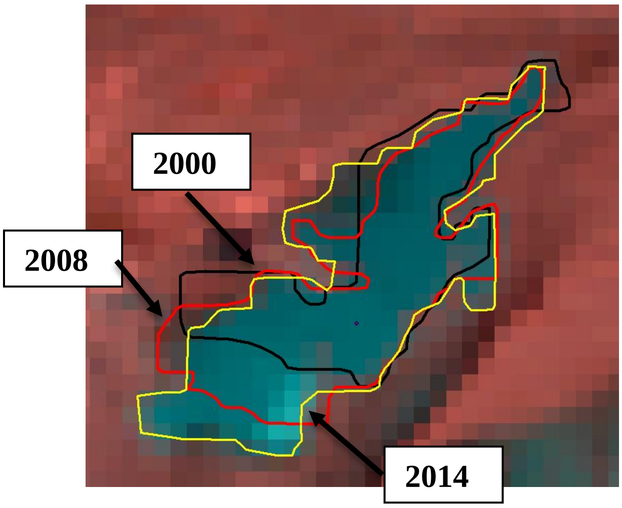
(viii) Information to be given to relevant institutions regarding the results and potential risks, thereby increasing the capability to plan for and prevent or mitigate the risks.

8. Present progress

In this project four study basins: Sutlej, Beas, Chenab and Ganga have been selected.

Galcier and Lake inventory have been prepared using all the data sets for four basins. Type of lakes have been defined. Area of all lakes have been computed. Vulnerable lakes have been identified for all the basins.

Data base (cross sections, volume and depth of lake etc.) have been determined for model application of MIKE 11.



Expansion of Lake in Satluj basin (2000-2014)

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/05
NMSHE STUDIES

1. **Thrust Area under XII five Year Plan**: Himalayan Cryosphere and Climate Change
2. **Project Team:**
    1. Dr. R. J. Thayyen, Scientist 'E', NIH, Roorkee - PI
    2. Dr. Sanjay K. Jain, Scientist 'G', NIH, Roorkee – Co-PI
    3. Dr. Sharad K. Jain, Director, NIH, Roorkee
    4. Dr. P. K. Mishra, Scientist 'C', NIH, Roorkee
    5. Dr. M. Arora, Scientist 'D', NIH, Roorkee
    6. *Collaborator: Dr. A. P. Dimri, Assoc. Professor, SES, JNU, New Delhi*
3. **Title of the Project:** Assessment of downstream impact of Gangotri glacier system at Maneri and Future runoff variations under climate change scenarios
4. **Objectives:**
    1. Modelling Glacier, Snow and Rainfall components in the stream flow at Maneri
    2. Assess the role of glaciers in regulating the inter-annual runoff variations at Maneri
    3. To establish Cryosphere response to climate variables through climate downscaling and runoff modelling.
    4. Assessment of future runoff variations at Dabrani/Harsil in response to the climate change.

5. Present state-of-art

River Ganga originates from the Gangotri glacier and fed by around 238 glaciers in the Bhagirathi catchment and 407 glaciers in the Alaknanda catchment covering around 1959 km^2 of the catchment area above Deoprayag. Discharge in these headwater tributaries of the Ganga is influenced by snow, rain and glacier melt. Melting glaciers of this region have raised serious concerns over the future trajectory of water availability in this crucial river system. There are conflicting viewpoints exists on the impact of glacier melt in the downstream flow regimes. IPCC 2007 report and many other studies in the Alpine systems suggested increased river flows during the early stages of glacier melt. However, Thayyen and Gergan (2010) distinguished between Alpine and Himalayan systems on the basis of annual precipitation distribution and flow regimes and pointed out that the runoff variations in the precipitation (Monsoon and winter snow) dominant systems such as Bhagirathi and Alaknanada basins are not dominated by the glacier discharge. Here precipitation variability plays the key role in runoff fluctuations with glacier melt helps to reduce the inter-annual runoff variability. Hence assessment of future runoff variation in this headwater streams required some robust future projections on precipitation and temperature. The impact of glacier melt dividend is found to be maximum for a basin with 20-30% glacier cover under the Alpine conditions. However, such assessment is non-existent in the Himalaya barring Dingad catchment, Garhwal Himalaya. As Gangotri is the largest glacier in the Ganga headwaters, extent and nature of its impact on downstream flow is critical issue for glacier resource management. The proposed project aims to understand this critical knowledge gap in the headwater regions of the Bhagirathi River at Maneri with 14.19% glacier cover. This catchment has 4205 km^2 area and 232 glaciers covering 596 km^2 (14.19%) The understanding of climate forcing on river flow under a data free regime is challenging. Key knowledge gap are precipitation and temperature gradients in the higher altitude regions. This knowledge gap will be addressed with collaborations with Jawaharlal Nehru University on atmospheric process modeling. Future runoff will be modelled using the future climate projections from this sub project.

6. Methodology

A) Discharge data of Maneri will be collected from the state agencies and inter-annual variations and long-term trends will be assessed.

B) Weather monitoring near Harsil: Weather data at the high altitude Himalayan region is very sparse. Hence orographic processes of the Himalayan slopes are poorly understood. Recent studies have shown that the orography is a key factor controlling the weather variables in the Himalaya. A full-fledged automatic weather station with four component radiometer, precipitation gauge and soil heat flux sensors will be installed near Harsil. Data from this weather station will be used for runoff modelling and climate downscaling.

C) Runoff modelling by SNOWMOD: Runoff modelling will be carried out by the established in-house model SNOWMOD. SNOWMOD is capable of providing snow, glacier, rainfall and base flow components separately. The glacier melt component in the discharge will be derived through modelling exercise. Glacier change in the Bhagirathi catchment during the past three decades will be estimated and correlations will be established between temperature/precipitation variations in the catchment with that of glacier change with the help of reanalysis data. Future glacier area change will be determined by using the inputs from the climate downscaling exercise and future runoff and glacier component will be modelled.

D) Climate downscaling and future predictions: Climate of the region is dominated by Indian winter monsoon and Indian summer Monsoon. Keeping such broad scale flow in mind climate downscaling will be done in conjuncture with the study of interaction of large scale monsoonal flow with existing variable topography and to study land surface processes in association with hydrological balance over the region of study with existing CORDEX simulation (from IITM, Pune), downscaling over the catchment region and modelling experiments. As it is understood that the region of study is of complex topography and hence such topography will not be truly represented within the model domain and hence dynamical downscaling will be used to established the atmospheric-topographic interaction in defining primarily precipitation forming processes. Statistical downscaling methods will be used to overcome the coarser horizontal model resolution problem and establish moisture-temperature interplay processes.

7. Research Outcome from the project:

Understanding of the downstream impact of Gangotri glacier system with glacier, snow & rainfall component and its probable future variability.

7. Cost Estimate:

a. Total cost of the project:	Rs. 153.716 lakhs
NIH	Rs. 80.42
JNU	Rs.73.296
b. Source of funding:	NMSHE-DST

8. Progress of the project

During the reporting period focus of the project was on runoff modelling at Maneri. Initial simulation is done for the period of 30 years (1990-2020) using SPHY hydrological model. For the first run, daily Remo data for Temperature (Minimum, Maximum and Mean) and precipitation (1975-2100) were provided by the JNU sub-project and utilized as the base meteorological data in the models.

In SPHY model HydroSheds SRTM DEM at 90 m spatial resolution is used for the generation of basin boundary, elevation information, slope and routing file generation. Randolf Glacier inventory 5.0 is used to demarcate the glacier cover area. Sentinal -2 multispectral remote sensing data has been used for the calculation (Kamble et al., 2013) of crop coefficients (Kc) for the individual land cover class. Which is further used to simulate potential evapotranspiration. Global soil maps from the Harmonized world soil database (HWSD) has been used to generate different root zone soil parameter's (Field Capacity, saturated content, permanent wilting point, wilting point & saturated hydraulic conductivity) and subzone physical soil parameters (field capacity, saturated content & saturated hydraulic conductivity) for the study area. For the preliminary run, constant values have been taken for root layer thickness, sub layer thickness and ground water parameters as we don't have spatially distributed data. The results obtained from this initial run shows acceptable match (R^2 = 0.8 after outlier removal) with the observed runoff and we hope that this can be further improved with the bias corrected/ subgrid temperature and precipitation data and improved values for root layer thickness, sub layer thickness and ground water parameters.

Preliminary results show that the average contribution of snow is 50% and that of Glacier is 14% followed by 30% rain and 2% base flow for thirty years. For observing the impact of climate change on different contributors of runoff we segregated 30 years (1990-2020) data in three decades (1990-2000, 2001-2010, & 2011-2020). The results show the increasing trend in the runoff contribution from glaciers. While contribution from glacier is 10% in the first decade (1990-2000), increased to 15% and 18% subsequently in the period 2001-2010 and 2011-2020. This preliminary results will be improved further with better quality climate data.

JNU-subproject has delivered bias corrected REMO data for Uttarkashi, Bhatwari, Bhojwasa for RCP2.6, 4.5 and 8.5 also of future projection s up to 2100. For seven stations with consistent data JNU sub-project has produced subgrid scale precipitation bias corrected precipitation as well as control and CLM45 for 1975-2005 period. Once the complete data set is available, the preliminary runoff model will be improved and an ensemble hydrological model result will be generated.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/06
NMSHE STUDIES

1. **Thrust Area:** Himalayan Hydrology

2. **Project Team**

Project Investigator	:	Dr. Sharad K. Jain, Director
Co-Project Investigator	:	Dr. R. J. Thayyen, Scientist 'E' & TL
Project Co-Investigators	:	Dr. Sanjay K. Jain, Scientist 'G'
	:	Dr. Surjeet Singh, Scientist 'E'
	:	Mr. M. K. Nema, Scientist 'C'
	:	Dr. P. K. Singh, Scientist 'D'
	:	Dr. P. K. Mishra, Scientist 'C'
	:	Mr. P. K. Agarwal, Scientist 'B'
	:	Dr. A. P. Dimri, Professor, JNU
	:	Dr. (Mrs.) Sangeeta Verma

3. **Title of the Project:** Observation and Modelling of Various Hydrological Processes in a Small Watershed in Upper Ganga Basin

4. **Objectives:**

   1. To establish relationship between climatic and hydrologic variables and their seasonal variations in Himalayan environment.
   2. To study the atmospheric dynamics including seasonal variations in atmospheric water budget, land-surface flux, orographic interactions during Indian summer and winter monsoon.
   3. To develop the understanding of the hydrological processes in the watershed though isotope geochemistry.
   4. To study the ground water dynamics in a lesser Himalayan watershed.
   5. To study the soil erosion characteristics and sediment routing of the watershed.
   6. To model various water balance components for a small watershed.

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

   Complex Climate – Hydrology interaction in the mountains is due to closer and dynamic land-atmospheric exchange on account of orographic updraft and drainage winds. Indian Summer and Winter Monsoon is a major factor controlling climate of the Himalaya (Thayyen and Dimri, 2014). Hence, understanding the atmospheric, land surface and hydrological processes and its linkages is key to our understanding of climate change forcing on the Himalayan hydrological system. We did not succeed in attributing the regional climate change contribution to the anthropogenic forcing till date. There is a clear need to generate hypotheses governing general behaviour across places and scales, with the ultimate aim to advance our understanding of the mountain hydrological processes. The project is envisaged to cover major components of the water cycle; starting from the seasonal atmospheric water budgeting, atmosphere-land surface interaction and feedback, surface water balance, soil moisture-soil temperature-sediment and water quality responses, groundwater dynamics and hydrological process studies and atmospheric moisture source assessment by stable isotope measurement.

6. **Methodology**

   Study Area: The small Himalayan watersheds (Henval & Jijali) in the upper Ganga basin in Tehri Garhwal district of the state of Uttarakhand are proposed for the study.

   i. Analysis of factors influencing local weather, land surface flux including soil temperature and diurnal & seasonal forcing at AWS site.

ii. Application of updated Regional Climate Model-RegCM4 (Giorgi et al. 2012) for atmospheric modelling along with CORDEX and subgrid land surface parameterization using mosaic-type scheme of the RegCM 3 (Giorgi et al. 2003).

iii. Water and sediment sampling for water quality investigations and modelling with advance use of isotopes.

iv. Develop understanding of the groundwater dynamics or interactions and recharge through installation of piezometer's longitudinally along the river, modeling and isotopic analysis.

v. Water balance modelling using field experiment based input data to understand the components of the hydrological cycle.

vi. Quantitative assessment of soil erosion and spatial distribution using USLE, RUSLE and MMF, RSSYM, WERM, SWAT Models with GIS and Remote Sensing in order to plan soil conservation measures.

7. Research Outcome from the Project: Enhanced understanding of the Lesser Himalayan hydrology-atmospheric interactions and climate change forcing aiding water resources management.

8. Cost Estimate: 134.32 lakhs

Total cost of the project	:	Rs. 134.32 lakhs
Source of funding	:	NMSHE-DST

9. Work schedule:

Activity	1st year		2nd year		3rd year		4th year		5th year	
	I	II	I	II	I	II	I	II	I	II
Development of procedure for scientific work										
Recruitment and deployment of Project Personnel										
Purchase of instruments and experimental setup										
Data generation and acquisition										
Data analysis and modelling (Isotopic analysis / Sediment Modelling)										
Atmospheric Dynamics (water budgeting / Land Surface Flux)										
Watershed water balance and budgeting										
Ground Water Dynamics										
Final Reporting										

10. Progress of Work:

Annual variation of Z_0

During the reporting period, annual variation of Roughness length (Z_0) is analysed at Henval and Kumargaon stations. It is found that Z_0 is higher at Henval than at Kumargaon. It varies from 0.01 to 0.46 at Henval and 0 to 0.07 at Kumargaon within a year. At Henval, Z_0 is comparatively lower in the leaf-off season than in the growing season and shows an apparent seasonal pattern whereas this seasonal variation is comparatively less at Kumargaon. Similar results are obtained from Table 1 which shows the monthly statistics of Z_0 at both the stations. These variations in Z_0 may be attributed to the topography and vegetation or canopy height at these stations. One of the major drivers of large seasonal variations in Z_0 is the distinct seasonal pattern of the LAI which increases from a minimum at the beginning of the growing season (early May) to a maximum in late June and starts to decrease in the middle of September (Zhou et al. 2006). At the beginning of the growing season, the LAI is relatively low and new leaves are very soft. The resistance to flow on the canopy surface is small, which results in small Z_0. With increases in the LAI and ageing of the leaves, the resistance and consequently roughness length increases. With the decrease in the LAI, Z_0 starts to decrease in the middle of September. During the non-growing season, low vegetation/canopy density results in lower Z_0.

Diurnal variation of Z_0

Diurnal variation of Z_0 is analysed on annual and monthly basis. At both the stations, annual diurnal variation shows minimum Z_0 around 9 AM. The maximum Z_0 is obtained around 3 PM at

Kumargaon whereas at Henval, maximum peak is not found. At Henval, analysis of monthly diurnal variation reveals that Z_0 is minimum around 10:00-11:00 AM for the months of October-April. For the rest months (May – September) of the year, distinct patterns are observed. No variation in Z_0 is obtained for the months of May and June. At Kumargaon, Z_0 is found highly fluctuating throughout the day for all months. These fluctuations are more for the months of January to June and comparatively less for the months of July to December. These fluctuations at Kumargaon may be linked with the heterogeneous topography of the terrain. In heterogeneous regions with undulating terrain, rough elements and their distribution change with wind direction and results in large fluctuations. These fluctuations are not found at Henval due to comparatively homogeneous and smooth topography.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/07
NMSHE STUDIES

1. Title - Water Census and Hotspot analysis in selected villages in Upper Ganga basin

2. Study team

1. Dr. P. K. Mishra, Scientist 'C', NIH, Roorkee - PI
2. Dr. Renoj J. Thayyen, Scientist 'E', NIH, Roorkee Co-PI
3. Er. M. K. Nema, Scientist 'C', NIH, Roorkee
4. Dr. Pradeep Kumar, Scientist 'C', NIH, Roorkee
5. Swagatam Das (JRF)
6. Hemant Singh (JRF)
7. Sanjay Kumar (PA)
8. Pankaj Kumar (PA)
9. Vishal (PA)

3. Objectives

The objectives of the project are:

a) To map water use pattern and livelihood linkages.
b) To map potential water hazard zones in the catchment.
c) To identify hotspot matrix components, hotspots analysis and adaptation strategies.

4. Sponsored by DST, New Delhi

5. Project Cost Rs. 90.99 Lakh

6. Brief Background

Himalaya is called the water tower of Asia. Himalayan rivers gather melt water from glaciers, snow and rainfall and deliver it to the millions living in the nearby plains across the Shivaliks. But the paradox lies in the fact this pristine water flowing in the Himalayan gorges have little use for the mountain people living on its slopes. Their livelihood is solely sustained by the springs and small rivulets as well as the rain and snowfall. The issues of the mountain people is often neglected in the Himalayan climate change discourse. This project is framed with the strong conviction that the sustainable Himalayan ecosystem is a mirage without addressing burning issues of the mountain people. Flash floods and landslides triggered by the frequent extreme events is becoming a regular feature for the mountain people. Reducing winter snowfall/extent/duration in consonant with the increase in winter temperature has already impacted the mountain hydrological regime as evident in the changing spring flow characteristics. The prime objective of the water census is to identify the water sources of the mountain villages and habitat, their issues and concerns, their habits and water use pattern. This fundamental understanding is necessary for evaluating the climate change impact on the mountain habitat and structuring and implementing adaptive strategies for sustaining the Himalayan ecosystem.

Water accounting, otherwise known as 'water census' is as important as other census activities for population, livestock, etc. carried out by the Government every decade. The Water Census is an emerging concept vital for creating Decision Support Capacity for water management agencies and policy makers. This provide a detailed accounting of water availability and use in a region. The main aim of the Water Census is to integrate diverse research on water availability and use as well as enhancing the understanding of relationship between water quality and water availability. Further, water census can be an umbrella platform in the hands of the stakeholders working in the field of water resources with information on water availability, water uses, potential water hazards, and most importantly the livelihood linkages. Livelihood- water linkage is core to sustaining the Himalayan ecosystem for the mountain people. Water disasters are increasingly become a threat to the mountain habitat and economic development under changing climate. Identification and management of potential water disaster zones are also key to sustaining Himalayan eco-system.

Considering these issues, this project is aimed to map and develop the water census (preliminary) for the Upper Ganga basin with information at micro (village) level on water availability, water use pattern and livelihood linkage, potential water threat, water structures not only for the major streams but also for tributary streams and rivulets close to habitat. It is also envisaged to identify the hot spot matrix components and its analysis to identify the most vulnerable sites (villages). This can only be accomplished by extensive survey at micro-level (village). The project could become a platform to integrate input from all other studies and information aiding policy formulation and strategic planning. Methodology developed and refined through this project can be replicated across the Himalayan region in subsequent stages of this mission.

An inter-linked approach to water resources management is envisaged in this project with following key components of water governance.

- Consider all water resources
- Address water demand as well as water supply
- Address wastewater management as well as water supply
- Involve all sectors and civil society stakeholders
- Promote access and gender equality
- Recognize the economic (livelihood), social, and environmental value of water.
- Recognize the water related threat and hazards for preventive measures (adaptation and mitigation strategies)

7. Methodology

The project will be executed as per the following roadmap:

Sampling

The study requires extensive survey work of two distinct nature, one is to develop water census of at least 100 selected villages distributed across the altitudes of the upper Ganga basin and another is of engineering survey of selected water structures/ sites. The engineering survey will capture L-section, X-section and other design flood parameters of selected bridges and culverts in the area.

The upper Ganga is divided into two major zones comprising of Alaknanda basin and Bhagirathi basin. Each of this major zones will be sub-divided into five sub-zones based on the elevation (altitude), climate etc. At least 10 villages will be screened from each sub-zones through scientific assessment and field visit as well as with discussion with other stakeholders.

Water census will be carried out by developing an elaborative matrix to capture various WRM components. A structured questionnaire and field mapping will be done to gather the information. An engineering survey will include mapping of the water structures, bridges, culverts etc. Landslide and earth quake hazard zonation maps will be integrated in the engineering survey.

Road map/ work components:

1. Preparation of GIS layers and Base line data collection
2. Selection of villages
3. Training of Resource Persons
4. Launch workshop
5. Stage I survey
    a. Attributes for water census
6. Mid-term Workshop
7. Diagnostics report
8. Stage II survey
9. Finalisation of Hotspot analysis
10. Development of adaptive strategies
11. Concluding workshop
12. Report preparation and submission

Activity chart (5 years)

Activity	1st year		2nd year		3rd year		4th year		5th year	
	I	II	I	II	I	II	I	II	I	II
Selection of project personnel										
Preparation of GIS layers and Base line data collection										
Selection of villages										
Training of Resource Persons										
Stage I survey										
Mid-term workshop										
Diagnostics report										
Stage II survey										
Finalization of Hotspot Analysis										
Development of adaptive strategies										
Concluding workshop										
Report preparation and submission										

9. Present progress

- Following field survey at village level have been completed during 2017-18 & 2018-19:
  - 27 villages in the Henvel valley (Tehri Garhwal) during 26-30 December, 2017
  - 22 villages in the stretch between Uttarkashi to Harsil during 02-07 January, 2018.
  - 39 villages in the Chamoli district (Joshimath) during 13-22 April, 2018.
  - 42 villages in Pauri Garhwal region during 07- 13 July, 2018.
  - 05 villages in Tehri Garhwal region during 13- 15 August, 2018.
- A one day Stakeholders' workshop was organized on 30th November, 2018 (Friday) at Indian Institute of Soil and Water Conservation (IISWC), Dehradun to deliberate various water related issues and challenges, probable interventions, and water-linked livelihood issues pertaining to Upper Ganga basin, wherein 15 agencies/ organizations working in the Himalaya participated.
- Hot spot matrix components finalized after deliberations with the experts from different organizations in the Stakeholders' workshop.
- Reported cloudbursts events during the periods from 2010-2018 were mapped, and investigated for spatial pattern w.r.t temperature, rainfall, etc.
- Out of five major districts falling in UGB, village level survey has already been conducted for four districts viz. Uttarkashi, Tehri Garhwal, Pauri Garhwal, and Chamoli. A fifth field level survey has been planned for the Rudraprayag district.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/08
NMHS STUDY

1. Title - Dynamics of Himalayan Ecosystem and its impact under changing climate scenario-Western Himalaya

2. Project team

National Team

Lead : Prof. A. P. Dimri, SES, Jawaharlal Nehru University, New Delhi, India
Co-Lead: Dr. Renoj J. Thayyen, National Institute of Hydrology, Roorkee, Uttarakhand, India

Institutional PI's

Dr. Subimal Ghosh (Indian Institute of Technology, Mumbai, Maharashtra, India)
Dr. Renoj J. Thayyen (National Institute of Hydrology, Roorkee, Uttarakhand, India)
Dr. P. K. Mishra (National Institute of Hydrology, Roorkee, Uttarakhand, India)
Dr. Sarat Kar (National Center for Medium Range Weather Forecasting, Noida, UP, India)
Dr. Soumya Prasad (Jawaharlal Nehru University, New Delhi, India)
Dr. Sumanta Bagchi (Indian Institute of Science, Bangalore, India)
Dr. Raman Kumar (Nature Conservation Foundation, Mysore, Karnataka, India)
Prof. A. P. Dimri (Jawaharlal Nehru University, New Delhi, India)

3. Objectives

The proposed project will address the following objectives, in particular for the Ganges and Indus within the western Himalayan Region, spanning select states:

1. *Develop database for climate* and ecological processes across the elevation gradients
2. Regional climate modeling with sub-grid orographic forcing, extreme hydrological events, biodiversity dynamics for the present (1970-2010)
3. Regional climate model simulations for climate change scenarios (upto ~ 2100)
4. Identify ecological restoration strategies to adapt to future climatic scenarios
5. Communicate findings to stakeholders

4. Present state-of-art

Developing a clear understanding of climate change impacts on Himalayan snow cover, glaciers, water storage and associated rivers, forest and ecosystems are key scientific questions which need to be assessed as these affect large a proportion of the Indian population living along the southern rim of the Himalayas. To address these issues we need a comprehensive understanding of climatic and ecological process for the Himalayan region. Due to limitations imposed by availability of climatic and ecological data layers, we have a limited understanding of impacts of future climates on ecological, hydrological and climate regimes in the Indian Himalayan Region.

The Himalayan region consists of diverse ecosystems, and encompasses a global biodiversity hotspot, and several Important Bird Areas. They span alpine, temperate, tropical non-monsoonal and monsoonal forest habitats, with heterogeneous topographic and landuse characteristics. As the world warms, several species and communities in mountain ecosystems have been documented to be moving to higher altitudes to keep track of suitable habitats. Faced with changing climates, species can (a) evolve adaptations to new climatic conditions, (b) adapt to new climatic conditions if they have pre-existing adaptations, (c) migrate to suitable habitats which have climatic conditions that match the species requirements or (d) go extinct if the species cannot evolve, adapt or migrate in response to changing climates (Corlett 2009). Anthropogenic climate change has already influenced biodiversity and ecological processes, and this is certain to increase in the coming decades. Changes in the distribution of species has been well documented in the temperate regions in the recent decades (Walther et al. 2002; Parmesan and Yohe 2003). There is limited baseline data to document such range shifts for the Himalayan region, and it has been forecast that a vast majority of species will display changes in distributions along rainfall and temperature gradients (Colwell et al. 2008; XU et al. 2009; Joshi et al. 2012))

5. Methodology (NIH)

Objective 1: NIH component of the project to install 50 AT/RH stations and 10 rainfall stations in the western Himalaya and develop data.

Objective 2: Climate data will be upended with IMD station data and mathematical formulations for temperature and precipitation gradients will be derived. This will provide better insights on the orographic processes controlling these variables. Climate envelope – biodiversity distribution relationships will be examined using niche models, including Maxium Entrophy models.

6. Research Outcome from the project

Deliverables (NIH): Fine resolution temperature data from 50 AT/RH stations and 10 precipitation stations for at least 3years. Regional slope environmental lapse rate of temperature and precipitation gradients.

7. Cost Estimate:

Total cost of the project: Rs. 2.1 Crore

a. NIH Rs. 58.76 Lakh

b. Source of funding: NMHS-MoEF

8. Progress of the project

Under this project 43 air temperature/ Humidty (AT/RH) stations were installed along five cross profiles covering U.K and H.P such as 1) Dak Pathar – Rohru 2) Dak Pathar- Kharsali 3) Roorke-Jhala 4) Kotdwara – Phata 5) Kathgodam- Joshimath. 13 stand alone stations were installed in the western Himalaya including Ladakh and Kashmir. Temperature and relative humidity data of these stations were collected till September 2018 and further analysis of Slope Environrmntal Lapse rate (SELR) is being carried out during the reporting period. The results show distinct lapserate of monsoon and cold aid regimes. Differing temperaure lapse rates of cold-arid and Alpine regime is also evident from the data. The summer lapse rates of the monsoon regime range between 6.6 to 5.5 K/km while for Cold-arid regime it vary between 7.7 to 9.6 K/km. Highest SELR is observed for the station pair Pandrass and Gumri as well as Kargi/ Gumri ranging between 11.1 to 13.5 K/km. These stations lie on the northern slopes of the Great Himalayan range. In contrast, the southern slopes of the Great Himalayan range between Gagangor and Gumri SELR during the same period renage between 7.5 to 6.1 K/km showing the distinction between different topoclimatic region of the Himalaya. In the monsoon regime the SELR between the base station with the ridge stations are signigficantly differ from the that of the valley bottom stations. Similarly, local valley- ridge SELR is found to be different from regional SELR. The results are based on only one season and expected to improve with more data and seasons in future.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/11

1. Title - Design and development of DSS (H) platform for Neeranchal National Watershed Project

2. Project team

a) Principal Investigator: Mr D.S. Rathore, Sc F

b) Project Co- investigators: Mrs Deepa Chalisgaonkar, Sc G
Dr. Jyoti Patil, Sc C
Dr. V C Goyal, Sc G
Dr. Santosh M. Pingale, Sc C

Approved budget

Source of funding: Neeranchal National Hydrology Project (NNWP), DoLR, GOI, WB
Date of commencement of sub project : April, 2016
Duration of sub project : 2 years

3. Objectives

To develop a web-based Decision Support System platform for deriving hydrological information required in preparation of DPRs for watershed development.

4. Statement of the Problem

The project is a component of the PMKSY scheme of GoI. The Sub-component 2.2 of the Project (*Decision Support System and Data Bases for Hydrology and Watershed Management*) would develop and pilot a new decision-support system (DSS) to support DoLR and nine project states to implement IWMP in a more comprehensive and scientific manner, particularly around hydrology.

5. Present State-of-Art

Various existing DSS at national and international level are reviewed. These are ICAR-IISWC DSS for Farm Pond 1.0 and Drop Structure 1.0, ICAR-CRIDA Jal-DSS Watershed Development Monitoring and Evaluation Tool (WDMET), 2016, software developed by ICAR-Central Institute of Agricultural Engineering (Bhopal) for design and data analysis, Fujian Normal University (China) DSS-WMRJ Watershed Management, Purdue University L-THIA etc.

6. Methodology

DSS-H is being developed at NIH as a web based system with thin client with capabilities of processing raster as well as vector data and uses open source tools and technologies. The applications provide tools for processing the data to create specific output relevant to users. DSS-H shall be enabled to act as data repository for hydro-meteorological, satellite remote sensing and GIS data. Two districts in each state and 4-5 watersheds in each district have been selected.

7. Location map/ study area

DSS will be developed for nine states. Two district in each state and six watershed in each district are selected. DSS will operate at scale of basin, sub-basin and watershed.

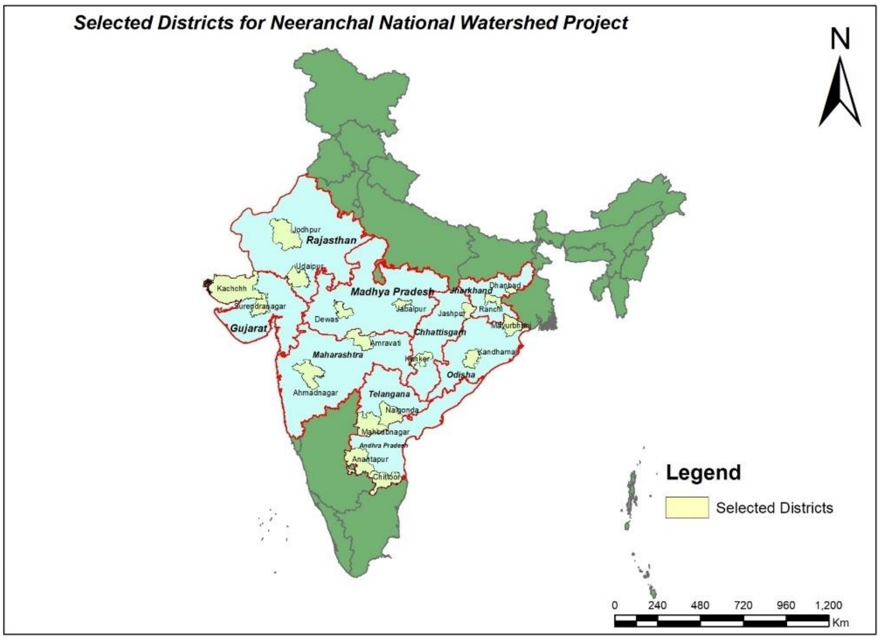


Figure 1: Neeranchal States and Districts

8. Approved action plan and time line

S N	Work Element	2017-18				2018-19			
		I	II	III	IV	I	II	III	IV
1	DSS model conceptualization								
2	Design of protocol of database generation								
3	Generic DSS development								
4	Design of GUI for DSS								
5	DSS customization as per user needs								
6	DSS testing and refinement								

9. Recommendations / suggestions in previous WG

None

10. Achievements

Main technologies/ software used in DSS development are PHP, OpenLayers, GeoServer, PostgreSQL, Python and PostGIS. Libraries such as Plotly for plotting and exporting of graphs, Bootstrap framework for responsive web layout and various Python libraries have been used. DSS-H has been divided into five modules viz., Data visualization, Planning, Sites and Structures, Impact assessment and DPR. User Acceptance Testing Server (Windows) and Production Server (Linux) setup was completed. User authentication, user profile, feedback capabilities were integrated. Livelihood vulnerability index tool was extended from block to district level. Data upload, rainfall analysis tools and Hydro-Bot were integrated. The Neeranchal web site was integrated with DSS-H. Peak discharge and watershed score card tools were added. Help feature was introduced for all tools. For viewing of data/ results, capability was introduced for selecting time range.

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/12

1. Title of Project: Investigating water stress using hydro-meteorological and remote sensing data, Purpose Driven Study (PDS), National Hydrology Project (NHP)

2. Project team:

c) **Principal Investigator:** Mr D.S. Rathore, Sc F

d) **Project Co- investigators:** Dr. L.N. Thakural, Sc C
Dr. Sanjay Kumar, Sc E
Mr. R. K. Jaiswal, Sc D
Dr. B. Venkatesh, Sc F
Dr. M.K. Jose, Sc D
Dr. T. Chandramohan, Sc D

Partner Organization: Water Resources Department, Rajasthan
Principal Investigator: Sh Sanjay Agarwal, Deputy Director
Co- investigators: Sh Shailesh Awasthi, Assistant Engineer

1. Statement of the Problem

Large part of states such as Maharashtra, Karnataka and Andhra Pradesh in Peninsular India are affected by drought condition frequently. Due to availability of surface irrigation, large areas in Andhra Pradesh and some areas in Maharashtra and Karnataka, the drought conditions are mitigated. Droughts and water stress conditions have socio- economic and environmental effects, necessitating scientific investigation of the conditions and mitigating it. Drought mitigation measures are moisture conservation, reduction in water demand and increase in supply.

4. Objectives

- Characterizing water stress using hydro meteorological, remotely sensed data and vadose zone modeling
- Analysis changes in water stress conditions due to drought response and mitigation measures
- Field level measurements of vadose zone moisture
- Forecasting and regionalizing drought indices
- Devising reservoir operating policy

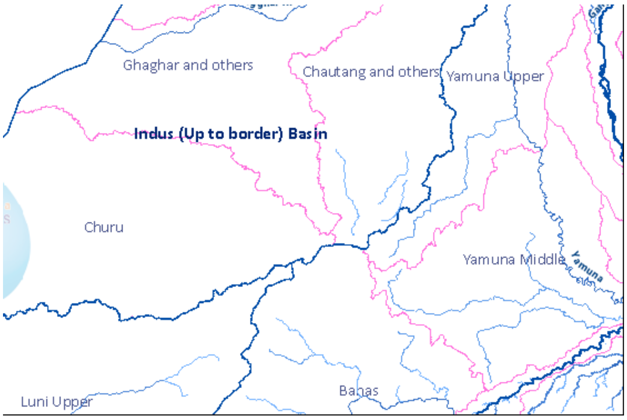
5. Present State-of-Art

Drought indices e.g. SPI, SODI, ADI, NADI utilize hydrometeorological and NDVI, NDWI, VCI, TCI, SMADI, VTCI, VAI etc. utilize remotely sensed data. PCA, clustering and DIT techniques were used for regionalization of indices. Forecasting of the indices was done using ANN, SARIMA and ARMA techniques.

6. Methodology

Drought indices will be estimated using hydro-meteorological and remote sensing data. Field experiment will be done to study soil moisture profile and relate this information with drought indices. Water movement will be simulated in vadoze zone. Soil moisture condition will be simulated with varying cropping pattern. Regionalization and forecasting of the indices will be carried out.

7. Location map/ study area



Ram Garh reservoir and its command was selected as study area. The dam is located on Banganga river. The study area falls in Jaipur and Dausa districts of Rajasthan. Catchment area of the dam is located in Arawali ranges. Area is located in East Rajasthan meteorological sub- division. Nearest IMD stations are Jaipur and Dausa. Main aquifer system consists of alluvium. Quartzite, gneiss, schist and granite have localised occurrances. Catchment area is nearly 700 sq. km. The dam was built in 1903. The reservoir is dry since 2006. Mean annual rainfall is 492 mm with 36% COV. Normal annual rainy days are 110.

8. Approved action plan and time line

<table>
<tr><th rowspan="2">Activity</th><th colspan="4">1st yr</th><th colspan="4">2nd yr</th><th colspan="4">3rd yr</th></tr>
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<tr><td>Scenario analysis</td><td></td><td></td><td></td><td></td><td></td><td></td><td style="background:#d9d9d9"></td><td style="background:#d9d9d9"></td><td style="background:#d9d9d9"></td><td style="background:#d9d9d9"></td><td style="background:#d9d9d9"></td><td style="background:#d9d9d9"></td></tr>
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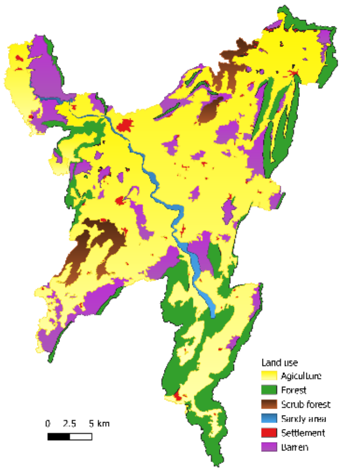
9. Recommendations / suggestions in previous WG

None

10. Achievements

Year	Objectives	Achievements
2018-19	Characterizing of water stress	Visit to WRD, Jaipur and Ramgarh catchment was done during 27- 28 December 2018. The reservoir was empty. In the catchment, double cropping is being done using sprinkler system with groundwater irrigation. Another visit was made during Feb 12- 16, 2019 for data collection. Data, namely annual rainfall, groundwater levels, aquifer and village maps, village wise static and dynamic groundwater resource and various reports were provided by State Groundwater Board. Cropping pattern information was provided by State Agriculture

		Department. Daily rainfall data was provided by State Water Resources Department. Details on availability of meteorological data with IMD was collected. Basin, river (using SRTM) and land use maps (using Google Earth) were prepared. Main land uses are agriculture, forest and barren and constitute approximately 59, 18 and 15% respectively.  Fig. 2 Land use map

ONGOING STUDIES
SPONSORED RESEARCH PROJECT: NIH/WRS/2019-20/13

1. Title of the Study: Seasonal Characterization of Gangotri Glacier melt runoff and simulation of streamflow variation under different climate scenarios.

2. Study Group : Dr Manohar Arora, Sc 'D'
Dr Sanjay Kumar Jain, Sc 'G'

3. Role of Team Members:

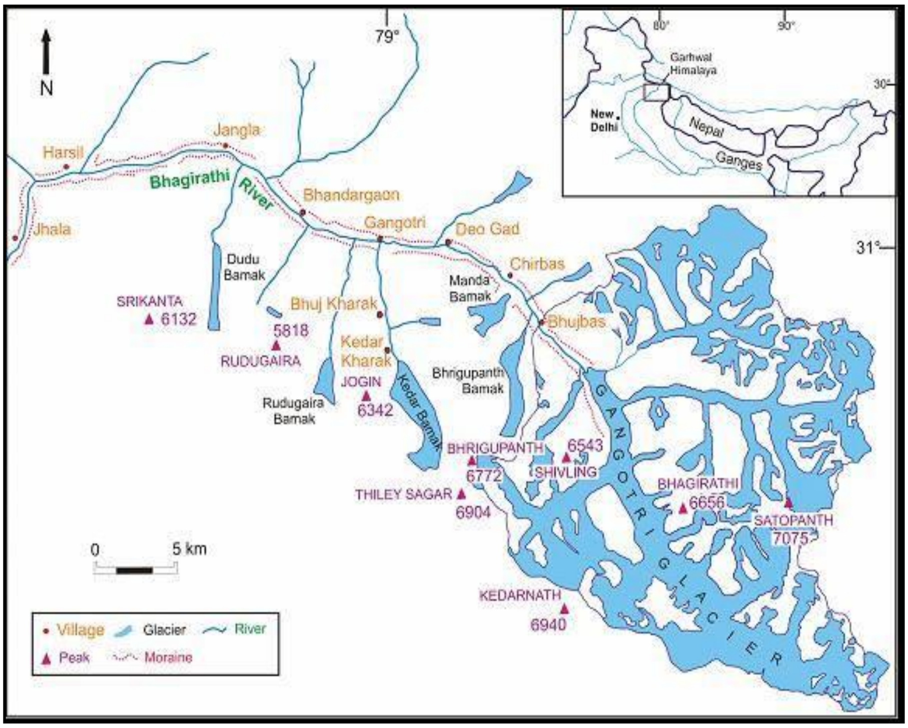
Dr Manohar Arora, Sc-D&PI: Conduction field investigations, analyzing data/information, report preparation and overall responsible for the study completion.

Dr Sanjay Kumar Jain, Sc-G&Co-PI: Guidance in development of methodology, modelling and structuring of report.

4. Type of Study : Internal. Project will be submitted to DST for funding.

Date of start : 01.04.2018
Scheduled date of completion: 31.03.2021.

5. Location Map:



6. Objectives: The objective of this study includes:

- Continuous observations of meteorological, hydrological and suspended sediment data for the melt season to determine monthly and seasonal specific water and sediment yield from the study glacier.
- Seasonal characterization of the glacier melt.
- Estimation of suspended sediment yield from the Glacier.
- Modeling the catchment runoff variation under different climatic scenarios.

7. Action Plan

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

8. Objectives vis-à-vis Achivements:

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 year 2018 commenced in the month of May 2018 and were carried out till October 2018. The data analysis and processing has been carried out.The discharge varied between 26 Cumec to 123 Cumecs in the ablation season.
To improve the hydrological model for simulating daily streamflow	The simulation of flow will be carried out after collection of three years of data.

Analysis of suspended sediment samples will be carried out in Soil Lab.

The meteorological and discharge data would be utilised in studying the characteristics of the Gangotri glacier under changing climate.

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.

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.

NEW STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2019-20/1

1. **Title :** Development of window based software for Flood Estimation

2. **Study Group :** Smt. Deepa Chaligaonkar, Sc 'G'
   Dr A K Lohani, Sc 'G'

3. **Duration:** April 1, 2019 to March 31, 2020 (One Year)

4. **Statement of the Problem:** The flood fright has always remained a cause of concern for the planners of various water-based projects. The estimation of flood for small or large catchments is pre-requisite for the success of any water resource project. Overestimation of flood could result in construction of uneconomical while underestimation of floods could lead to failure of project. Right from the inception, a number of computer program have been developed at NIH for flood studies. However, they were written in FORTRAN/Basica languages which did not provide user-friendly environment to the field users. In view of this, it is proposed to develop a WINDOW based software to carry out flood estimation.

5. **Objective** : To develop a WINDOWS based Software package for flood estimation.

6. **Methodology:** The software will have a user friendly environment for carrying out the various computations involved in flood estimation. The software will include following main components:
   - Channel Routing Parameters Estimation
     - Estimation of Muskingum Parameters using Graphical Method
     - Estimation of Muskingum Parameters using Method of Moments
     - Estimation of Muskingum Parameters using Optimimtion Technique
     - Routing of Inflow Hydrograph using Available Muskingum Parameters
     - Routing of Inflow Hydrograph using Muskingum Cunge method
   - Reservoir Routing
     - Reservoir Routing using Mass Curve Method
     - Reservoir Routing using Modified Puls Method
     - Reservoir Routing using Goodrich Method
     - Reservoir Routing using Coefficient Method
   - Unit Hydrograph Development
     - Processing and analysis of rainfall data
       - Filling up of Missing Data
       - Consistency Check of a Record using Double Mass Curve technique
       - Computation of Areal Average Rainfall
       - Computation of Variation of Depth with Area
       - Distribution of Daily Rainfall into Hourly Rainfall
     - Rating Curve Analysis and Computation of Discharge
       - Computation of Discharge from Velocity Measurements
       - Development of Rating Curve
       - Conversion of Stage Values to Corresponding Discharge Values
     - Excess Rainfall and Direct Surface Runoff Computations
       - Baseflow Separation and Computation of ERH Volume
       - Separation of Baseflow using Straight Line Technique

- Unit Hydrograph Derivation
  - Unit Hydrograph for Gauged Catchments
    - ✓ Conventional Method
    - ✓ Unit Hydrograph using Collin's Method
    - ✓ Unit Hydrograph using Conventional Nash Model (Method of Moments)
    - ✓ Unit Hydrograph using Conventional Nash Model (Optimisation)
    - ✓ Unit Hydrograph Given Parameters of Conventional Nash Model
    - ✓ Unit Hydrograph using Integer Nash Model
    - ✓ Unit Hydrograph using Clark Model (Optimisation)
    - ✓ Unit Hydrograph using Given Parameters of Clark Model
  - Unit Hydrograph Derivation for Ungauged Catchments
    - ✓ Unit Hydrograph using Snyder's Method
    - ✓ Unit Hydrograph using Regional Formulae Developed by CWC
    - ✓ S hydrograph Computation
    - ✓ Unit Hydrograph of Changed Duration using Superimposition Method
    - ✓ Change of Unit Duration of Unit Hydrograph using S - Curve Method
    - ✓ Development of Dimensionless Hydrograph
    - ✓ Development of Unit Hydrograph from a Dimensionless Hydrograph

- UH Application on Small Catchment for Flood estimation
  - Computation of Direct Surface Runoff Hydrograph
  - Computation of Direct Surface Runoff (DRH) and Error Functions
  - Computation of Design Flood
- Flood Estimation for Large Catchments

The software will be capable of presenting the results in tabular as well as graphical form. Descriptive data forms will be prepared for easy preparation of data files. It is proposed to include online help for all the options/sun options at each stage of running the package.

7. Research Outcome of the Project:

A WINDOWS based Software package for flood estimation will be developed. The reasonable accurate estimation of floods by using the methodology and software would certainly be helpful in designing and the construction of economically as technically feasible structures. It is expected that the field engineers will find this package useful.

RESEARCH MANAGEMENT AND OUTREACH DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. V C Goyal	Scientist G & Head
2	Er. Omkar Singh	Scientist F
3	Dr. A R Senthil Kumar	Scientist F
4	Er. Digamber Singh	Scientist C
5	Dr. (Mrs.) Jyoti Patil	Scientist C (LCU)
6	Sri. Rohit Sampatrao Sambare	Scientist B
7	Sri Subhash Kichlu	PRA
8	Sri Rajesh Agrawal	SRA
9	Sri N R Allaka	RA

NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्ठा मयोभुवः

Work Programme for the year 2018-19

SN	Title of Project/Study	Funding	Study Team	Duration	Status
Internal Study					
1	Study on effect of climate change on sediment yield to Pong reservoir	NIH	A R Senthil kumar (PI) J V Tyagi, S D Khobragade , Manohar Arora	Apr 2015-Sep 2018	NIH
2	Effect of climate change on evaporation at point scale	NIH	Digamber Singh (PI) A R Senthil Kumar, Manohar Arora	Jun 2014-Jun 2018	NIH
3	Bathymetric survey and water quality monitoring of selected ponds in Bundelkhand region for development of water management plan	NIH	Digamber Singh (PI) Omkar Singh Rajesh K.Nema Hukam Singh Subhash Kichlu N R Allaka	Apr 2018-Mar 2020	NIH
4	Conservation of ponds in Ibrahimpur- Masahi Village and performance evaluation of natural treatment system	NIH,CEH (UK) & IITR	**NIH**: Omkar Singh (PI) V C Goyal, Rajesh Singh, Digamber Singh, Subhash Kichlu, Rajesh Agrawal, NR Allaka **IITR**: Himanshu Joshi **CEH**: Laurence Carvalho, Mike Clarke	Apr 2018-Mar 2020	NIH, CEH (UK) & IITR
	Sponsored Projects				
1	Vulnerability assessment of identified watersheds in Neeranchal Project States	NNWP	Jyoti P Patil (PI)	Jul 2017-Jun 2019	DoLR (under NNWP)
2	Hydrological modelling in Bhagirathi basin up to Tehri dam and assessment of climate change impact	NMSHE	A R Senthil kumar (PI) J. V. Tyagi, M. K. Goel S. D. Khobragade P. C. Nayak, Manohar Arora	Mar 2016-Mar 2021	DST (under NMSHE)
3	Rejuvenation of village ponds for identified villages in Muzaffarnagar and Meerut districts	MoWR-funded project	V C Goyal (PI) Omkar Singh, Digamber Singh, Rajesh Singh, Subhash Kichlu, Rajesh Ahrawal, NR Allaka, Rakesh Goel	Apr 2017-Mar 2020	MoWR, RD & GR
4	Development of water allocation plan for a Neeranchal watershed in Chhattisgarh	NNWP	A R Senthil kumar (PI) T R Nayak, Jyoti P Patil Rajesh Agarwal	Apr 2018-Mar 2020	DoLR (under NNWP)
New Sponsored Project					
1	Rejuvenation of village ponds in identified villages of Baghpat, Ghazibad and Meerut districts of Uttar Pradesh	MoWR-funded project	Omkar Singh (PI), Rajesh Singh, V C Goyal, Digamber Singh, Subhash Kichlu, Rajesh Agrawal, NR Allaka & Project Staff	Apr 2017-Mar 2020	MoWR, RD & GR

1. **Title of the study:**

Study on effect of climate change on sediment yield to Pong reservoir

2. **Study Group:**

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

3. **Date of start:** 1 April 2015

4. **Duration of the study:** 3 Years

5. **Whether externally funded or not:** No

6. **Objectives of the study:**

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

7. **Statement of the problem**

The developmental activities in the catchment area contribute high sediment load which affects the expected performance of the reservoir. Increase of anthropogenic emissions of green house gases will aggravate climate change and thus average temperature of atmosphere, no of extreme events of rainfall and intensity will increase. In Himalayan region, the increase in high intensity rainfall will contribute more sediment to the reservoir. It is important to estimate the change in sediment yield under the projected different climatic scenarios to assess the performance of the Pong reservoir.

8. **Brief methodology:**

Sediment yield model

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

Climate Scenarios

The different scenarios of climatic conditions such as RCP2.6, 4.5, 6 and RCP8.5 are obtained from CMIP5 models available from different institutes.

Computation of sediment yield under different scenarios

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

Revision of elevation-area-capacity table

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

9. Results achieved with progress/present status

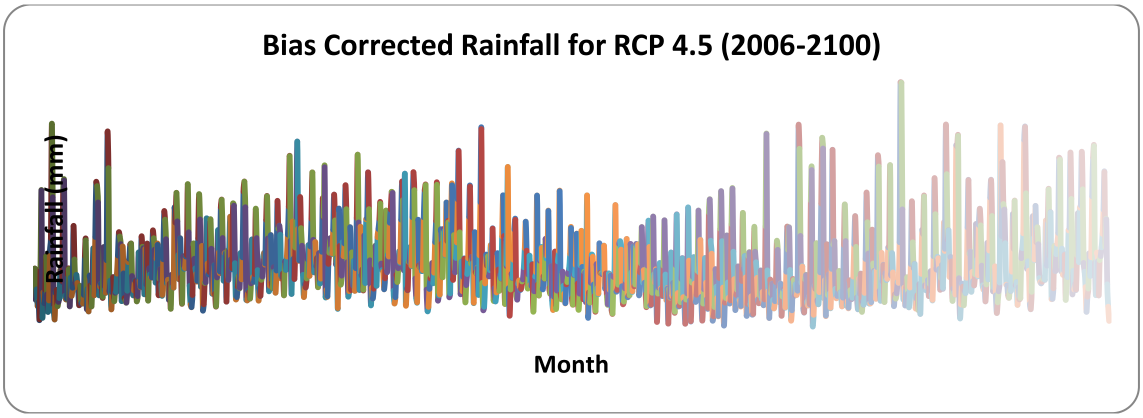
The SWAT model is setup with the required input data to simulate the sediment yield from Beas Catchment up to Nadaun bridge (Pong reservoir). The input data such as DEM, LULC and soil type are generated from different sources such as NASA, National Bureau of Soil Survey and Land Use Planning (NBSSLUP) and NRSC. Grid based meteorological data such as daily rainfall, minimum and maximum temperatures are obtained from Indian Meteorological Department (IMD) and rainfall, minimum temperature, maximum temperature, solar radiation, wind velocity, relative humidity are obtained from European Centre for Medium-Range Weather Forecasts (ECMWF) (ERA Interim data). The parameters for the simulation of discharge and sediment yield have been calibrated manually by trial and error method by considering the data from 1993 to 1996 for calibration and 1999 to 2002 for validation. The coefficient of determination for simulation of sediment yield during calibration and validation are 0.95 and 0.92 respectively.

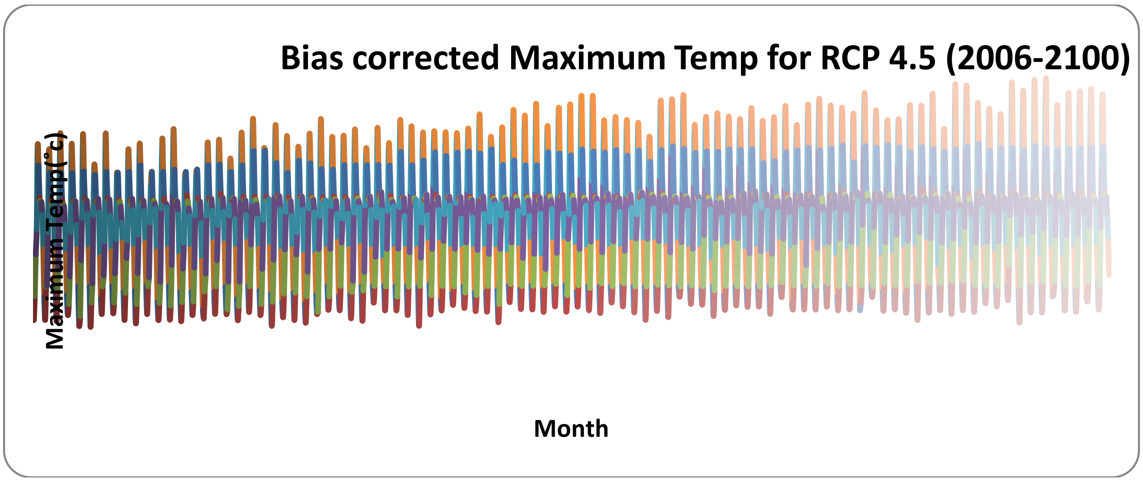
Significant predictors of rainfall, maximum and minimum temperature have been determined using the averaged IMD gridded data of rainfall, maximum and minimum temperature and the rainfall, maximum and minimum temperature from NCEP-NCAR reanalysis data for the period from 1961-2005 by SDSM tool. The significant predictors for rainfall, maximum and minimum temperature are given as follows:

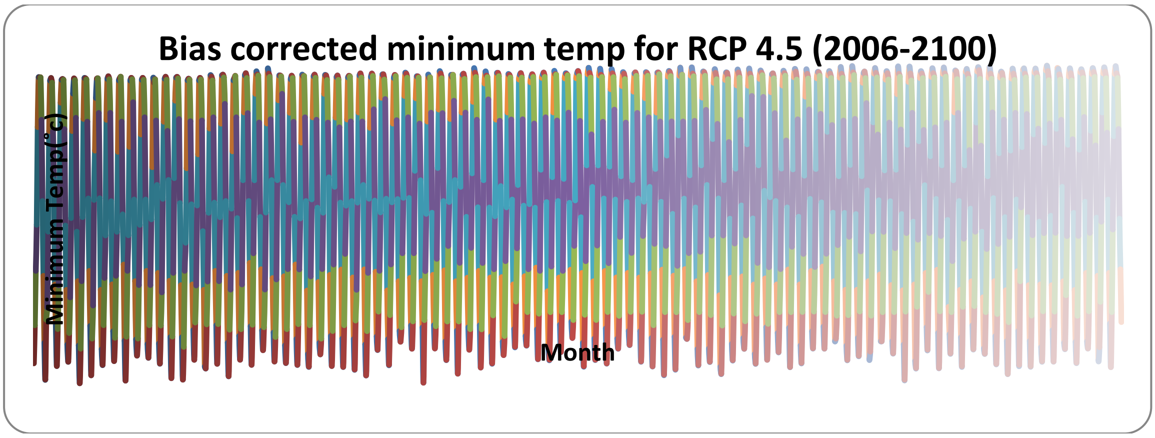
Variable	Significant predictors
Rainfall	Mean sea level pressure (pa), total precipitation (mm), surface airflow strength (m/s), specific humidity at 500 hpa (%), surface specific humidity (%)
Maximum temperature	Mean sea level pressure (pa), wind direction at 500 hPa, airflow strength at 500 hPa (m/s), vorticity at 500 hPa, geopotential height at 500 hPa (m), mean temp (˚C)
Minimum temperature	Mean sea level pressure (pa), wind direction at 500 hPa, vorticity at 500 hPa, geopotential height at 500 hPa, surface specific humidity (%)

The calibration and validation of significant predictors of NCEP-NCAR data have been carried out by SDSM with averaged IMD gridded data. The averaged IMD gridded data for the period from 1961 to 1995 and from 1996 to 2005 have been considered for calibration and validation of significant predictors of rainfall, maximum and minimum temperature respectively. The coefficient of determination for the calibration and validation of significant predictors for rainfall are 0.98 and 0.96 respectively. The coefficient of determination for the calibration and validation of significant predictors for maximum temperature are 0.97 and 0.97 respectively. The coefficient of determination for the calibration and validation of significant predictors for minimum temperature are 0.99 and 0.98 respectively.

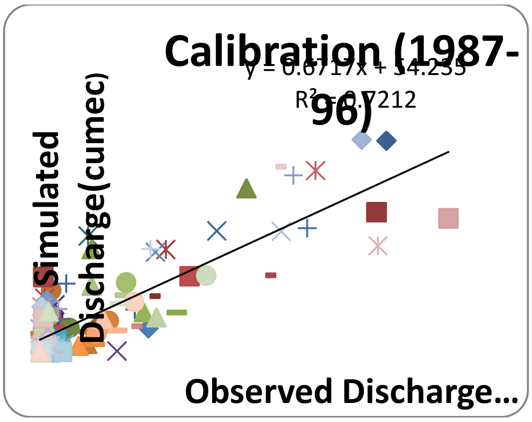
The rainfall, maximum and minmum temperature values for the scenario of RCP2.6, 4.5 and 8.5 for the period from 2006 -2100 have been downscaled from CanESM2 predictors from the regression equation developed for NCEP/NCAR significant preditctors. The downscaled values of the rainfall, minimum and amximum temperature for the scenarios of RCP2.6, 4.5 and 8.5 have been bias corrected by probality of exceedence method. The bias corrected values of rainfall, maximum and minmum termperature for the scenario of RCP 4.5 from 2006 to 2100 is given as follows:

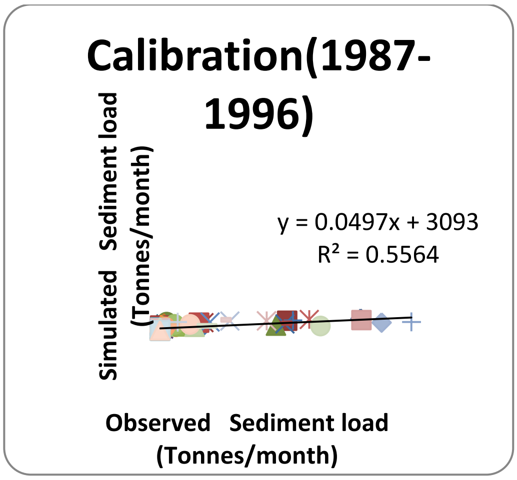


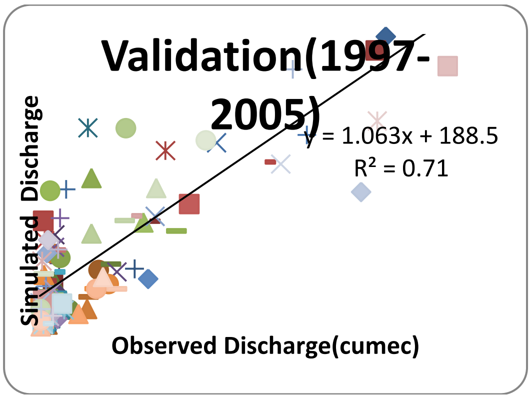


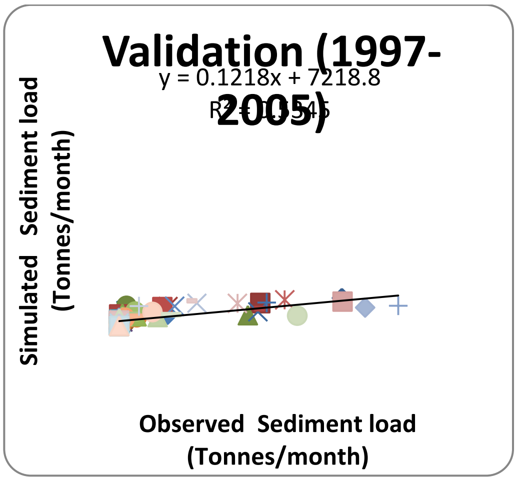


The SWAT model has been calibrated again with the IMD averaged gridded data of rainfall, maximum and minimum temperature and solar radiation, wind velocity, relative humidity from SWAT site and the performance of the calibration and validation for streamflow and sediment yield are given as follows:









Statistical parameters	PONG Watershed			
	Calibration (1987-1996)		Validation(1997-2005)	
	Runoff	Sediment	Runoff	Sediment
R^2	0.72	0.55	0.70	0.53
NSE	0.71	0.41	0.68	0.39

10. Expected date of completion: **30 June 2019 (Actual date of completion: 31 March 2018)**

11. Revised timeline

Sl. No.	Work Element	2015-16		2016-17		2017-18		2018-19		2019-20	
		H1	**H2**	**H1**	**H2**	**H1**	**H2**	**H1**	**H2**	**H1**	**H2**
1	Literature Review										
2	Collection and processing of Hydrometeorological data and purchase of satellite imagery and soil maps										
3	Data preparation for SWAT										

4	Simulation of Sediment yield by SWAT										
5	Downscaling of data from GCM Models										
6	Simulation of sediment yield with the data from future climatic scenarios										
7	Revision of elevation-area-capacity table of the reservoir by using the future projected sediment yield										
8	Preparation of interim report										
9	Preparation of final report										

1. **Title of the study:**

Bathymetric survey and water quality monitoring of selected ponds in Bundelkhand region for development of watershed management plan.

2. **Study Group:**

Digambar Singh Sc C, RMOD
Er. Omkar Singh Sc F, RMOD
Er. Hukum Singh Sc B
Er. Rajesh Nema Sc B
Shri Subhash Kichlu PRA, RMOD
Shri N R Allaka RA, RMOD

3. **Date of start**: 1, April 2018

4. **Duration of the study**: 2 Years

5. **Whether externally funded or not:** No

6. **Objectives of the Study:**

a. Bathymetric survey of identified ponds and estimation of water storage capacity of ponds.
b. Assessment of water quality of ponds for irrigation and fisheries etc.

7. **Statement of the problem**

Ponds and reservoirs are the life line of Bundelkhand region. Agriculture and fisheries are the main occupation of the people living in this region. These occupations are totally depending on the ponds and reservoirs. The Bundelkhand region is facing frequent droughts due to regular shortfall of rainfall in the region. The average rainfall of the study area is 800–900 mm. (Ramesh et al. 2002), But, during the last six years Bundelkhand region received only 400–**450 mm** annual rainfall and more over the lithological condition are also not favorable to develop good aquifer . Therefore, available rainwater is only viable option to be harvested for meeting various demands viz. agriculture, cattle, fisheries etc. The most of the ponds become dry by the end of March/April due to high evaporation loss and different uses. Therefore assessment of availability of water from surface water bodies is very important to sustain irrigation, fisheries and other water needs as well as to provide security to farmers. This study aims to estimate the quantity and quality of available water in the selected water bodies to know the present status and plan a strategy for the future by carrying out bathymetric survey and water quality investigations.

8. **Brief methodology:**

(a) **Remote/Pedal boat (using sonding weight) will be used for bathymetric survey**.

The Echo Boat is a hand portable remote controlled catamaran platform developed for bathymetric survey applications. The light weight, wide profile and water tight connection provide stability, ruggedness and portability.

(b) Assessment of water quality & Eutrophication Status

The water quality parameters, viz. temp., pH, electrical conductivity, total dissolved solids, dissolved oxygen, turbidity, chlorophyll and blue green algae are to be monitored using multi-parameter Sonde (YSI, 2014) The water quality of different ponds is to be assessed based on above mentioned limited water quality parameters as monitored in field for fishery (Bhatnagar & Devi, 2013), irrigation (CPCB, 1978/2007-8), and drinking (IS: 10500, 2012), respectively

.Eutrophication status can be estimated using Carlson TSI . The TSI for Chlorophyll is given below:

Trophic Status of Ponds

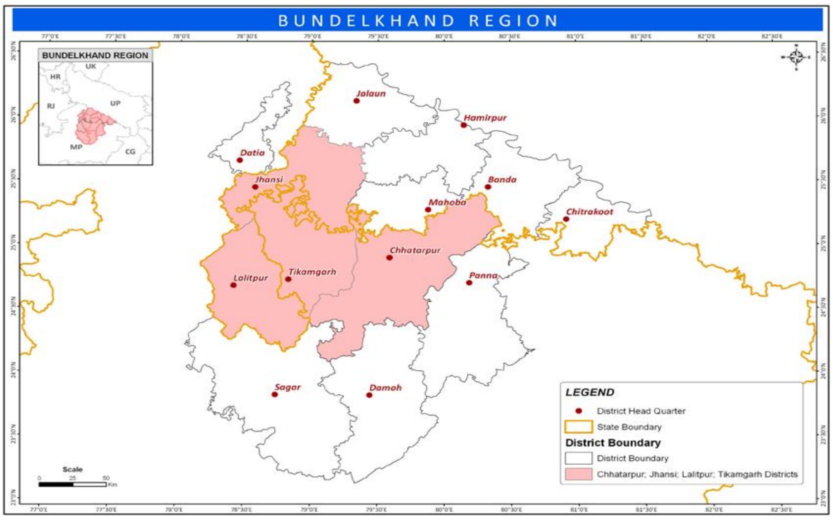
POND NAME	VILLAGE	BLOCK	Chl	TSI (Chl)	TROPHIC STATUS
Madan Sagar	Ahar	Baldevgarh	9.3	52.5	Eutrophic
Gwal Sagar	Baldevgarh	Baldevgarh	30.2	64.0	Eutrophic
Sarkanpur Tal	Sarkanpur	Baldevgarh	23.5	61.6	Eutrophic
Bhitawar	Bhitawar	Baldevgarh	16.7	58.2	Eutrophic
Delta Talab	Baisa	Tikamgarh	243.7	84.5	Eutrophic
Mamaun	Mamaun	Tikamgarh	25.7	62.4	Eutrophic
Rigora	Rigora	Tikamgarh	15	57.2	Eutrophic
Laxmanpura	Rigora	Tikamgarh	12.2	55.1	Eutrophic
Deepsagar	Kari	Tikamgarh	35.6	65.6	Eutrophic
Raiya Tal	Mawai	Tikamgarh	12.6	55.5	Eutrophic
Premsagar	Mawai	Tikamgarh	21.7	60.8	Eutrophic
Madansagar	Jatara	Jatara	14.5	56.8	Eutrophic
Bahran Tal	Bahran Tal	Jatara	7.8	50.8	Eutrophic
Chaturkari	Chaturkari	Jatara	24.3	61.9	Eutrophic
Ghura	Ghura	Palera	32.4	64.7	Eutrophic

(c) Determining the Water quality index

Water Quality Index (WQI) is a standard index created and designed by The National Sanitation Foundation (NSF). The WQI is one of the most widely used tools of all existing water quality procedures. The overall results of nine separate tests can be used to determine WQ index of any water body. Water quality index is a 100 point scale that summarizes results from a total of nine parameters given below. Temperature, pH, Dissolved Oxygen, Turbidity, Fecal Coliform, Biochemical Oxygen demand, Total Phosphates, Nitrates, Total Suspended Solids.

9. Study area

The study area covers Jhansi (U.P.), Lalitpur (U.P.), Tikamgarh (M.P.), Chhatarpur (M.P.) districts. Map of the area is given below:



10. Action plan and timeline

Sl. No.	Work Element	2018-19				2019-20			
		Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
1	Literature review								
2	Collection of water sample and measurement of water quality parameters by SONDE								
3	Bathymetric Survey of the ponds								
4	Water Quality Analysis								
5	Computation of the volume of the ponds								
6	Analysis of the suitability of water for irrigation and fisheries								
7	Report writing								

11. Data requirements

Dissolved oxygen, Ph, EC, TDS, Chlorophyll, Temperature, Depth, Conductivity, Salinity, ORP, BGA, FDIM, Phosphate etc.

1. Results achieved with progress/present status

i) Literature review related to water quality

ii) Bathymetric survey by eco boat and water quality of the pond water by Sonde is yet to be carried during 2019 after post monsoon.

12. Deliverables:

i) Bathymetric map
ii) Water quality status and evaluation report for irrigation
iii) Research papers

13. **Adopters of the results of the study and their feedback:** Agriculture and fisheries department of the concerned region

1. **Title of the Study:** Conservation of ponds in Ibrahimpur-Masahi village and performance evaluation of natural treatment system.

2. **Study Group:**

Lead Organization	**Project Investigator** Er. Omkar Singh, Scientist F, RMOD
	Co-Investigators Dr. V. C. Goyal, Scientist G & Head (RMOD) Dr. Rajesh Singh, Scientist C, EHD Er. Digambar Singh, Scientist C, RMOD
	Scientific/Technical Staff Sh. Subhash Kichlu, PRA Sh. Rajesh Agarwal, SRA Sh. N.R. Allaka, RA
Partner Organization	Dr. Laurence Carvalho & Team, Centre for Ecology & Hydrology, Edinburgh, United Kingdom

3. **Type of Study:** Internally Funded (CEH-UK will cover the expenses towards DO sensors including installation & Maintenance, sampling & analysis of specific parameters of pond and wastewater, etc.)

4. **Nature of Study:** Applied

5. **Date of start:** April 2018

6. **Scheduled date of completion:** March 2020

7. **Duration of the Study:** 02 Years

8. **Study Objectives:**

i) Water quality investigations of ponds, wastewater and groundwater.
ii) Performance evaluation of CW based Natural Treatment System.
iii) Assessment of health of water body through ecological indicators.
iv) Planning for use of treated wastewater.
v) Societal impact assessment and Mass Awareness Activities.

9. **Statement of the Problem:**

In our country, most of the traditional sources of water (i.e. ponds) in villages are on the verge of disappearing/shrinking due to encroachment, siltation and water quality deterioration and face severe eutrophication mainly due to untreated input of wastewater in the ponds. In this context, the Institute has rejuvenated a pond (Village: Ibrahimpur Masahi, Tehsil-Bhagwanpur, Dist. Haridwar) by establishing CW based Natural Treatment System (NTS). The rejuvenated ponds with treated wastewater will be used for agricultural use and other livelihood activities such as fishery. The performance evaluation of this system is necessary to establish its feasibility and replicability in other village ponds receiving continuously input of domestic wastewater into the village ponds. Therefore, it proposed to monitor important water/wastewater quality parameters at two ponds, namely Ibrahimpur Masahi (receives village wastewater through constructed wetland) and Masahi Kala (control pond/reference pond: pond without any treatment system). The Centre for Ecology & Hydrology (CEH-Edinburgh, United Kingdom) is also associated in this study.

10. Approved Action Plan/Methodology:

In this study, the pond, wastewater, and groundwater (hand-pumps) quality will monitored per standard procedures (APHA 2012). Along with CEH-UK team, the health of the water body and possible its impact on society will also be assessed. Options for the use of treated wastewater will be explored. The water quality assessment for agriculture purposes (BIS-1987/2001; USDA 1954) and Fishery will be performed as per recommended procedures including development of WQ Indices. Eutrophication of ponds will be assessed using Carlson's Trophic State Index (Carlson, 1977).

11. Timeline:

S. N.	Work Element	2018-19				2019-20			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Review of literature								
2	Water quality and depth monitoring of pond, groundwater, and wastewater								
3	Data compilation & performance evaluation of NTS								
4	Assessment of health of water body								
5	Societal impact assessment								
5	Mass awareness activities								
6	Report Preparation								

12. Objectives and achievement during last twelve months:

Objectives	Achievements
Water quality and depth monitoring of pond, groundwater, and wastewater	• WQ Samples were collected in April (06 GW+01 PW+01WW), May (04 GW + 01 PW + 01 WW) and July (01 PW). • The organoleptic, major cations and major anions were analyzed. • Trace metal analysis of the samples completed. • The frequency of WQ sampling w.e.f. Nov. 2018 has been increased upto weekly/fortnightly level to check the performance of CW based NTS. • Total 78 samples have been collected weekly/fortnightly at Ibrahimpur Masahi (Grit Chamber inlet-01, GC outlet-01, CW outlet-0, pond water sample-01) and at Masahi Kala Pond (Wastewater Inlet-01, Masahi Kala Pond-01) and analyzed for critical parameters. • The plant density of Constructed Wetland is also been estimated periodically. • Productivity experiment was conducted in November. • The WQ samples were also collected by CEH-UK for specific parameters (viz. methane, biota, etc.) during Nov. 2018 for analyzing at CEH-UK.
Mass Awareness/Outreach Activity	• Outreach activity conducted for villagers/Gram Panchayat Members and concerned local State Govt. officials at village Ibrahimpur Masahi (on dated

	(20/11/2018). • Transfer of CW-NTS to Gram Panchayat was done on 20.11.2018. The SOP for proper operation and maintenance of NTS was also provided to Gram Pradhan, Ibrahimpur Masahi.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
Nil	-

14. Analysis & Results:

Natural treatment system i.e. constructed wetland has been established in Ibrahimpur Masahi village. To check the efficiency of constructed wetland, water quality of the samples from the treatment units and pond at Ibrahimpur Masahi were analyzed weekly/fortnightly. In addition, the water quality of influent and pond at Masahi Kala village, without any interception, was also monitored as a reference/control pond. The samples were analyzed for indicator parameters like pH, EC, DO, BOD, COD, NO_3-N, PO_4 and NH_3-N. The pH of the Ibrahimpur Masahi pond was high as compared to the control pond. This is an indication of the lower organic input to the pond. The pond with high biodegradable organic load has low pH due to high CO_2 and organic acids due to decomposition of the organic matter. The DO that is a critical parameter for aquatic life is also observed improved in case of Ibrahimpur Masahi pond. The average DO value in Ibrahimpur pond was 2.32±0.67 mg/l with minimum value 0.8 mg/l whereas in Masahi Kala pond the average value was 0.74±0.50 mg/l with minimum value non detectable. The average BOD value in Ibrahimpur pond was 34.4±8.8 mg/l in comparison to 130.0±26.0 mg/l in the control pond at Masahi, clearly indicating the positive impact of the constructed wetland. Further, outreach activity was conducted in the month of November Ibrahimpur–Masahi Village and the constructed wetland was handed over to village Gram-panchayat.

15. End Users / Beneficiaries of the Study: Villagers & Stakeholders

16. Deliverables: Performance Evaluation Report of CW-NTS, Societal impact of rejuvenated water body, Eutrophication Trends of Ponds,

17. Major items of equipment procured: Nil

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

19. Data procured or generated during the study: Pond and groundwater quality and groundwater level data.

20. Study Benefits / Impacts: The outcome of the project will be beneficial for the villagers in a sense that it will increase the groundwater recharging capacity of the pond and also enhance the groundwater water quality of the area. This study will address the issues related to contamination of village ponds and the outcomes from the study can be utilized by the policy makers for addressing the issues in other villages.

21. Involvement of end users/beneficiaries: Villagers and Gram panchayats

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

23. Shortcoming/Difficulties: Societal issues

24. Future Plan: As per approved action plan

1. **Title of the Study:**

Vulnerability assessment of identified watersheds in Neeranchal Project States

2. **Study group:**
Dr Jyoti P Patil and nodal scientists from Regional centres (Bhopal, Patna, Kakinada, Belgaum)

3. **Type of Study**: Sponsored- Neeranchal National Watershed Programme (NNWP)

4. **Date of start:** 01.07.2017

5. **Scheduled date of completion:** 30.06.2019

6. **Duration of the Study:** Two years

7. **Study Objectives:**
The aim of the study is to assess the vulnerability to climate change for the identified watersheds of 9 Neeranchal Project States.

8. **Statement of the Problem:**

Assessing vulnerabilities is the process of identifying, quantifying, and prioritising the vulnerabilities in a system. Vulnerabilities from the perspective of climate change means assessing the threats from potential hazards to population, infrastructure, development goals etc. VAs can help to improve adaptation-planning, allocation of resources and raising awareness about climate change at different levels. Vulnerabilities cannot be measured directly; it has to be inferred with the help of various variables.

9. **Brief methodology**

Focus of this study has been on generating Livelihood Vulnerability Index (LVI) by IPCC approach and Composite method for watersheds under NNWP. The IPCC-LVI approach would facilitate the identification of areas, which are vulnerable to climate change and need special attention towards adaptation. The socio-economic, environmental, agriculture, water resource, health, climate and forest indicators of vulnerability will employed and classified into adaptive capacity (A), sensitivity (S), and exposure (E). The LIV-IPCC approach was applied on block level assessment of vulnerability to climate change in Neeranchal districts. The micro-watershed level vulnerability assessment was also done using Vulnerability Composite Index. Identification and classification of indicators for vulnerability assessment is always subjective keeping in view the importance of indicators in the spatial context, availability of quantitative/measurable data, time series availability of data and to some extent any indicator having proxy representation. They will be classified manually as it is not possible to carry out such a classification statistically.

10. **Timeline:**

S. N.	Work Element/ Milestone	2017-18	2018-19		2019-20
		H2	H1	H2	H1
1	Select a set of indicators to assess the vulnerability of people, livelihoods and ecosystem				
2	Collection of data from secondary sources				
3	Calculate Livelihood Vulnerability Index using the IPCC approach				
4	Highlight areas that are most vulnerable and				

	need to be protected as well as the areas that need improvement				
5	Suggest measures/ strategies to cope up with climate change events in future				

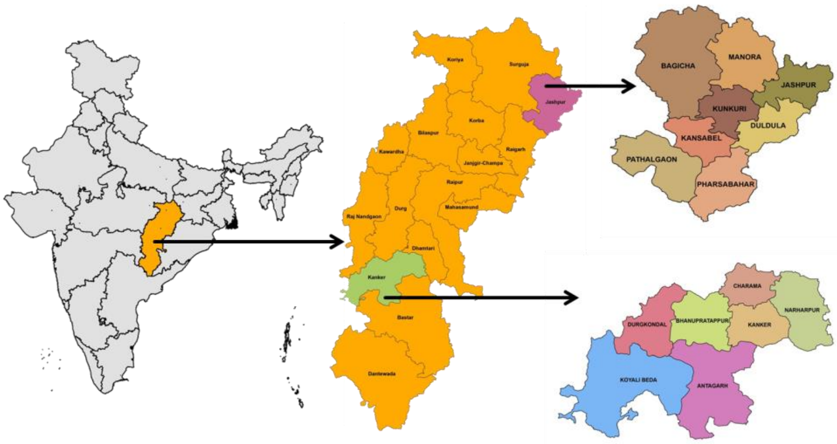
11. Objective and achievement during last six months:

Work Element as per timeline	Achievement
Highlight areas that are most vulnerable and need to be protected as well as the areas that need improvement	Most vulnerable blocks were highlighted in Jashpur and Kanker district using LVI-IPCC approach The vulnerable villages were highlighted using LVI composite methodology.
Vulnerability reasoning	Vulnerability reasoning was scaled out for most vulnerable watersheds

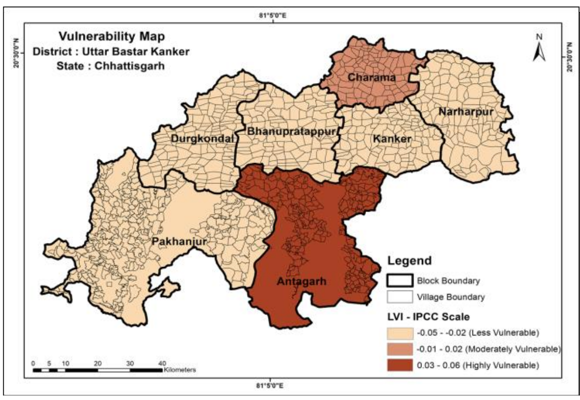
12. Recommendation / Suggestion: NA

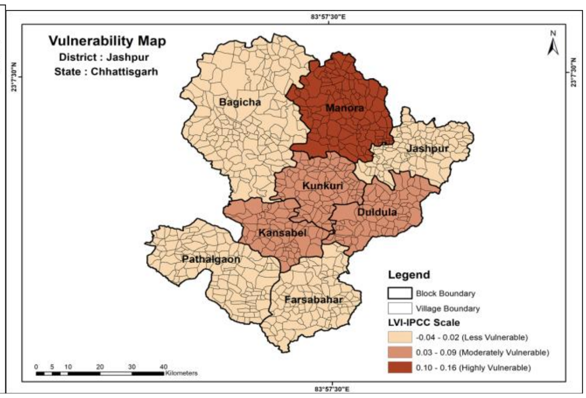
13. Analysis & Results:

1. The two districts, Kanker and Jashpur, Chhattisgarh were selected on pilot basis for block level assessment using LVI-IPCC approach.



2. Vulnerability assessment on block level for Jashpur and Kanker is given below:



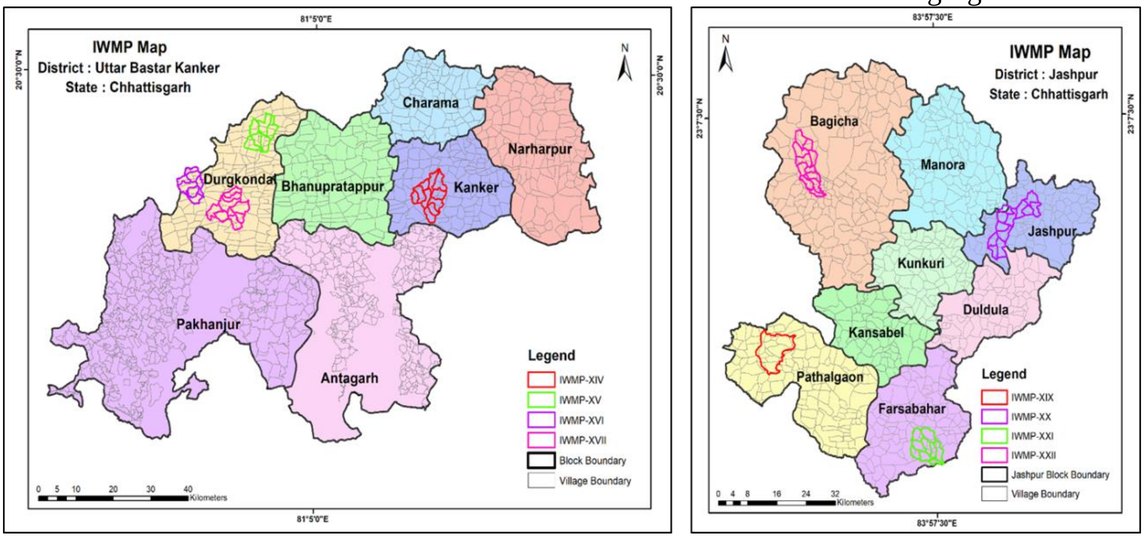


Vulnerability order of Kanker district:
Antagarh > Charama > Bhanupratappur > Durgkondal > Narharpur > Kanker > Pakhanjur

Vulnerability order of Jashpur district:
Manora > Kansabel > Duldula > Kunkuri > Farsabahar > Pathalgaon > Jashpur > Bagicha

Vulnerability reasoning	
Kanker (Antagarh)	Jashpur (Manora)
✓ Highest % of wasteland ✓ Non-access to drinking water ✓ High level of agricultural dependency ✓ Higher % of child population, marginal workers	✓ Trend of climate shows increasing temperature and decreasing rainfall ✓ High level of agricultural dependency ✓ Non-access to drinking water ✓ Highest % of marginal workers

3. Assessment of micro-watersheds using Composite vulnerability approach was done for Kanker district. The locations of mico-watersheds in both districts are shown in following figure.



The village wise vulnerability order in IWMP-14 is as below:
Kalmuchche > Dhantulsi > Salhebhat > Kirgapati > Tultuli > Barchegondi > Mode > Kurustikur > Mandri

Vulnerability order of IWMP-15:
Gudphel > Ghotulmunda > Jharripara > Hilchur > Mokha > Pujari Para > Nedgaon > Kodakhurri > Kalangpuri > Goyanda > Taraighotia >Amaguhan > Tarhul > Pedawari > Chhindgaon > Bhursa Tarandul > Seoni > Damkasa

Vulnerability order of IWMP-16:
Otekatta > Nelchang > Guddatola > Godpal > Kodekurse > Karaki > Uikatola > Bhurke > Chaurgaon

Vulnerability reasoning	
IWMP-14 (Kalmuchche) IWMP-15 (Gudphel) IWMP-16 (Otekatta)	✓ Non-access to drinking water ✓ Lowest number of ponds, tanks, lakes ✓ Lowest % of forest cover ✓ Highest % of landless farmers ✓ Lowest cropping intensity and crop diversification index ✓ Highest % of wasteland

4. The methodology and results of the LVI-IPCC approach are incorporated in DSS-H through Livelihood Vulnerability Index Module.

14. **End Users / Beneficiaries of the study:** Integrated Watershed Management Programme

15. **Deliverables:** Areas which are most vulnerable to climate change and need further attention will be highlighted

16. **Major items of equipment procured:** Nil

17. **Lab facilities used during the study:** Nil

18. **Data procured or generated during the study: -**

19. **Study Benefits / Impacts:** Outputs of the study will be used in the development of DSS(Hydrology), and later on for preparation of DIP/ DPR by the respective line departments

20. **Involvement of end users/beneficiaries:** IWMP

21. **Specific linkage with Institution and /or end users/beneficiaries:** Various line departments (KVKs, Irrigation, WRD, Agriculture, Industry)

1. **Title of the study:**

   Hydrological modelling in Bhagirathi basin up to Tehri dam and assessment of climate change impact

2. **Study Group:**

   Dr. A. R. Senthil kumar Sc F, NIH, Roorkee
   Dr. J. V. Tyagi, Scientist 'G', NIH, Roorkee
   Dr. M. K. Goel, Scientist 'G', NIH, Roorkee
   Dr. S. D. Khobragade, Scientist 'F', NIH, Roorkee
   Dr. P. C. Nayak, Scientist 'D', Deltaic Regional Centre, NIH, Kakinada
   Dr. Manohar Arora, Scientist 'D', NIH, Roorkee

3. **Date of start:** 1 January 2016

4. **Duration of the study:** 5 Years

5. **Whether externally funded or not**: DST

6. **Objectives of the study:**

   a. To model stream flow/snow melt runoff in Bhagirathi Basin up to Tehri dam.
   b. To model sediment yield at Tehri dam.
   c. To investigate the impact of likely future changes in climate on stream flow and sediment yield up to Tehri dam using future climate scenarios.
   d. To assess impact of afforestation/deforestation on sediment yield in the basin.
   e. To assess the operation policy of the Tehri dam in light of the climate change impact.

7. **Statement of the problem**

The developmental activities in the catchment area contribute high sediment load which affects the expected performance of the reservoir. Increase of anthropogenic emissions of green house gases will aggravate climate change and thus average temperature of atmosphere, no of extreme events of rainfall and intensity will increase. In Himalayan region, the increase in high intensity rainfall will contribute more sediment to the reservoir. It is important to estimate the change in sediment yield under the projected different climatic scenarios to assess the performance of the Tehri reservoir. The study on impact of afforestation/deforestation on sediment yield in the basin is also important for effective watershed management.

8. **Brief methodology:**

Sediment yield model

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

Streamflow simulation

The streamflow up to Tehri reservoir is modeled by SNOWMOD with the input data of elevation, rainfall, aspect, temperature and snow cover area. The performance of SWAT is compared with SNOWMOD in simulating the discharge.

Climate Scenarios

The different scenarios of climatic conditions such as RCP2.6, 4.5 and RCP8.5 are obtained from CMIP5 models available from different institutes.

Computation of streamflow and sediment yield under different scenarios

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

Revision of elevation-area-capacity table

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

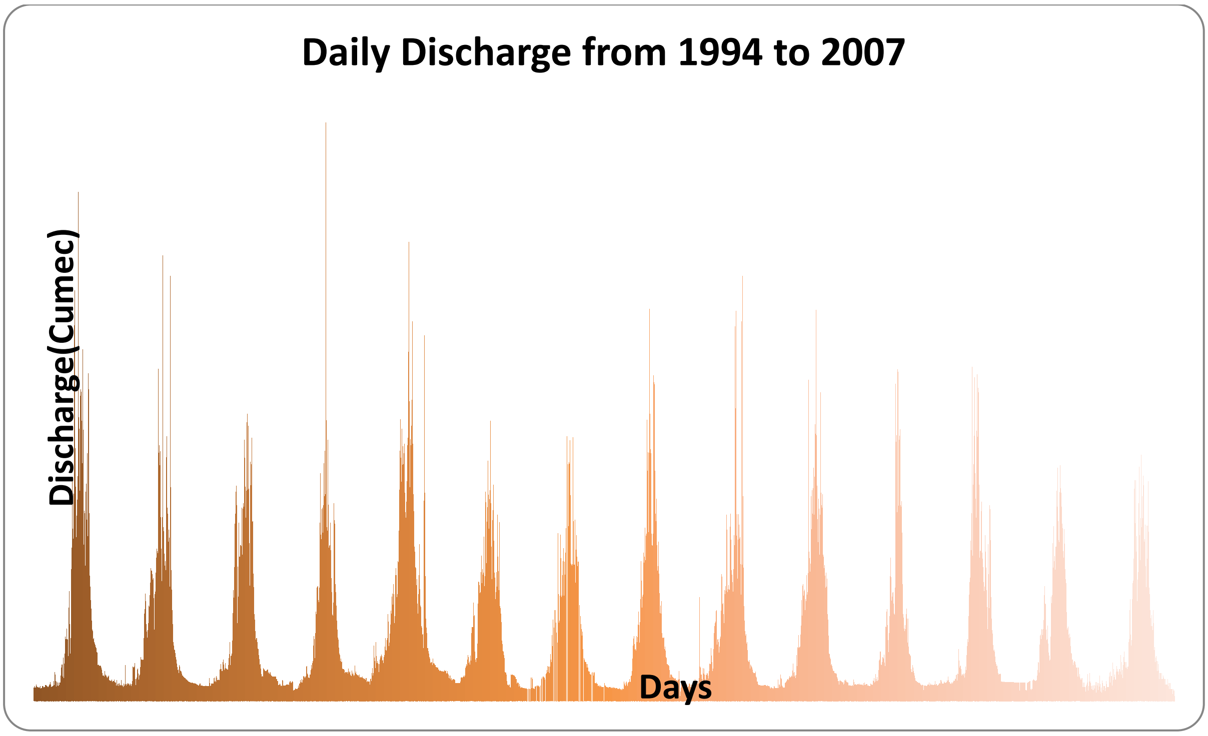
The impact of afforestation/deforestation on sediment yield is analyzed by the simulation of sediment yield using SWAT by increasing/decreasing the LULC.

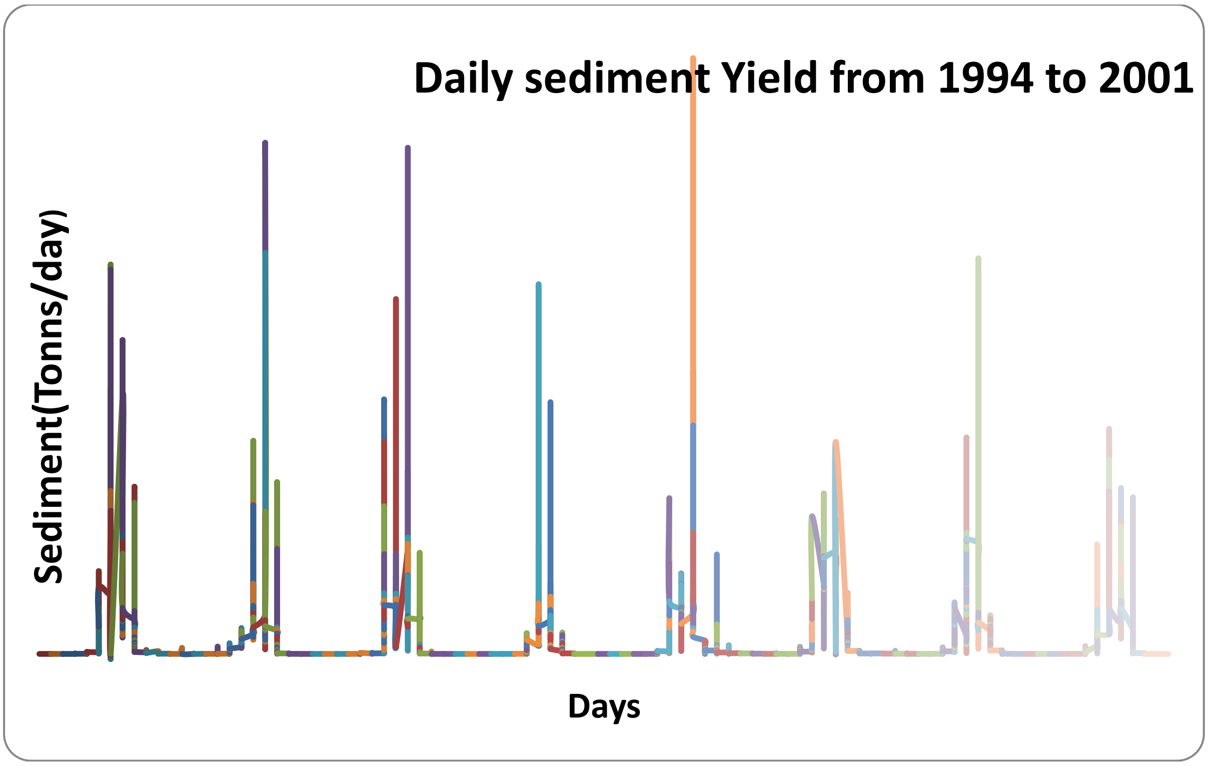
The rule curves for operating the reservoir are modified by considering the revised elevation-area-capacity curve in light of increased/increased sediment yield.

9. Results achieved with progress/present status:

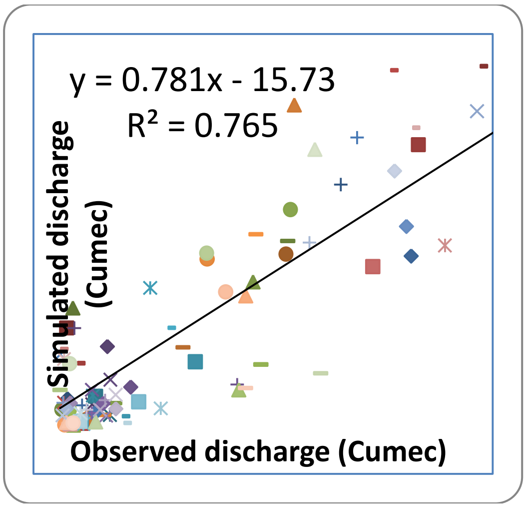
The sediment yield at Tehri reservoir is modelled by Soil and Water Assessment Tool (SWAT). The inputs such as DEM, LULC and Soil map for running the ARCSWAT have been generated using different sources available in the web sites of different organisations such as NASA, National Bureau of Soil Survey and Land Use Planning (NBSSLUP), Indian Council of Agricultural Research, Harmonized World Soil Database (HWSD) International Institute for Applied Systems Analysis **(**IIASA) and National Remote Sensing Centre (NRSC). The daily rainfall, maximum temperature, minimum temperature, Solar radiation, wind speed, relative humidity (from surface pressure, mean temperature and dew point temperature) have been obtained from **ERA INTERIM, European Centre for Medium Range Weather Forecasts (ECMWF).**The discharge and sediment yield at Tehri dam has been simulated using the gird based input data by taking the parameters randomly with SWAT .

The daily rainfall values at Mukhim, Tehri, Bhatwari, Dunda, Maximum and Minimum temperature at Mukhim, relative humidity and wind speed at Mukhim have been obtained from IMD. The daily discharge (1994 to 2007) and sediment yield (1994 to 2001) have been obtained from THDC, Rishikesh and are given as follows:

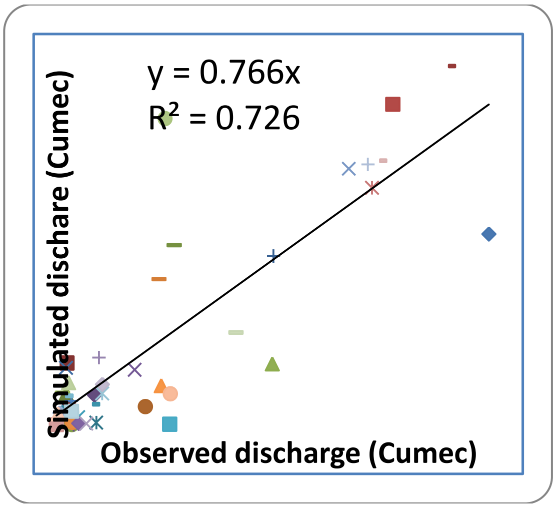




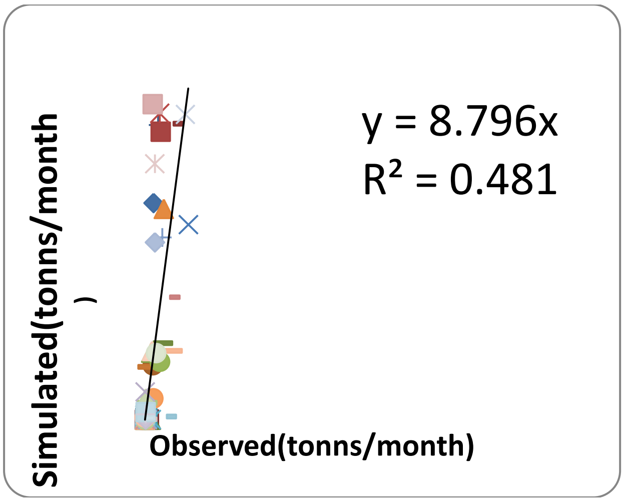
The parameters of the SWAT are calibrated for discharge and sediment yield by considering the data from IMD and THDC, Rishikesh. The graphical comparison of the observed and simulated discharge at Tehri dam and the modelling of sediment yield are given as follows:



Calibration result for the period from 1996 to 2003



Validation result for the period from 2004 to 2007



The downscaling of rainfall, maximum and minimum temperature from CanESM2 using SDSM is being done

10. Outcome of the study

The output of the study will give an idea of increased sediment yield and streamflow from the future climatic scenarios to the state department officials for managing the various demands based on the available the storage in the reservoir on priority basis. The impact of afforestation/deforestation on sediment yield will be used for planning cropping pattern to reduce the sediment yield

11. Expected date of completion: 31 January 2021

12. Timeline

Activity	2016-17		2017-18		2018-19		2019-20		2020-21	
	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2
Collection and processing of Hydrometeorological data and purchase of satellite imagery										

Data preparation for SNOWMOD and SWAT										
Simulation of streamflow by SNOWMOD										
Simulation of Sediment yield by SWAT										
Downscaling of data from GCM Models										
Simulation of streamflow and sediment yield with the data from future climatic scenarios										
Revision of elevation-area-capacity table of the reservoir by using the future projected sediment yield										
Analysis of the reservoir performance with the revised elevation-area-capacity table and projected streamflow										
Writing of the final report										
Training workshop										

1. **Title of the Study:**

Development of water allocation plan of a Neeranchal watershed in Chhattisgarh

2. **Study group:**

Dr A. R. Senthil kumar, Sc "F" RMOD
Dr. T R Nayak, Sc "F", RC, Bhopal
Dr. Jyoti P Patil, Sc "C", RMOD
Sh. Rajesh Agarwal, SRA, RMOD

3. **Date of start:** April 2018

4. **Duration of the study:** 2 Years

5. **Whether externally funded or not:** NNWP

6. **Objectives:**

a. To model the different components of hydrological process.
b. To evolve water allocation plan for various uses by scenario analysis.

7. **Statement of the problem**

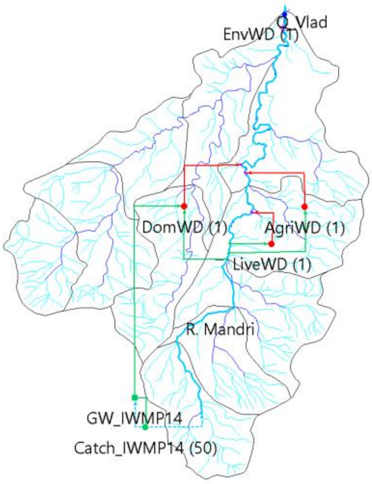
The demand for water from agricultural, industrial and domestic uses is continuously increasing due to the development in their respective sectors. The fixed availability and uncertainty over the occurrence of water increases the complexity of allocation of water to the competing demands from various sectors. It is imperative to evolve management plans for the allocation of water in efficient way to achieve optimum crop yield without compromising the demands for domestic and industrial uses. Allocation of limited water resources among agricultural, domestic and industrial uses requires the integration of supply, demand, water quality and ecological considerations. The Conventional supply-oriented simulation models are not always adequate for exploring the full range of management options for water allocation. Water Evaluation And Planning (WEAP) tool integrates all tools in a robust way for integrated water resources planning.

8. **Methodology**

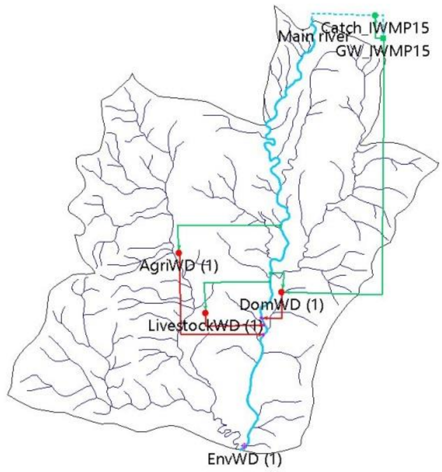
The water allocation plan among different uses in a Neeranchal Watershed in Chhattisgarh is evolved by setting up of WEAP tool. The inputs to WEAP tool such as water demand from various sectors, priority of the demand, catchment details, hydrologic conditions and inflows, catchment hydrology (river flow, ground water, lakes/reservoir/storage tanks, springs, other storage structures etc), supply preference (operating rules/policy), return flows, minimum flow requirements, economic variables such as cost water transmission etc are prepared from the data obtained from various sources such as irrigation department, IMD, CWC, census department. The hydrological processes occurring in the catchment will be modeled and will be compared with the measured discharge time series. After the proper calibration of the model, the demand sites will be added into a model framework and different scenarios will be generated to assess the gaps in the water demand and supply and water availability at different locations and at the different period of time. The different water allocation plan will be evolved based on the scenario analysis to achieve optimum crop yield.

9. **Results achieved with progress/present status:**

The WEAP model has been setup for micro watersheds IWMP14, IWMP15 and IWMP16 using the climate data such as rainfall from IMD data, reference evapotranspiration for crops, population data and livestock details, area under different crops, priority for supply from DPR, crop coefficient, etc. The runoff computation is done using the simplified coefficient. The schematic diagram of the model setup for IWMP 14 and 15 are given as follows:



Schematic diagram for IWMP 14



Schematic diagram for IWMP 14

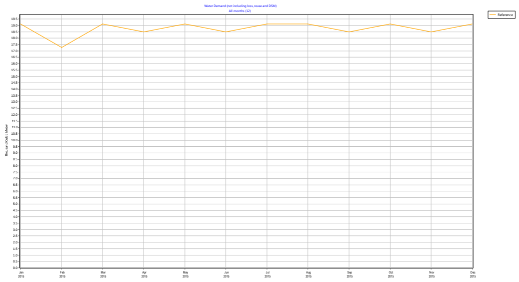
The catchment area of IWMP 14 and IWMP15 are 66.73 and 46.56 sqkm respectively. The details of crop, its area and water requirement for each crop for IWMP 14 are given as follows:

Sl. No	Type of crop	Area in m^2	Annual water use rate in m^3
1	Gram_Kharif	3500	60
2	Kulthi_Kharif	9200	60
3	Maize_Kharif	6750	55
4	Paddy_kharif	227786	125
5	Urad_Kahrif	2270	55
6	Gram_Rabi	6500	34
7	Kulthi_Rabi	2000	60
8	Peas_Rabi	4000	35
9	Sunflower_Rabi	260	35

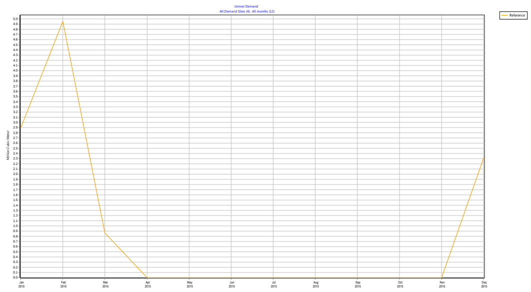
The details of livestock and its water requirement are given as follows:

Sl. No	Type of livestock	Population	Annual water use rate in m^3
1	Buffaloes	134	56.575
2	CB cows	516	73
3	Draft animal	1694	91.25
4	Goat	1094	3.65
5	Indigenous Cows	427	49.275
6	Sheep	35	3.65

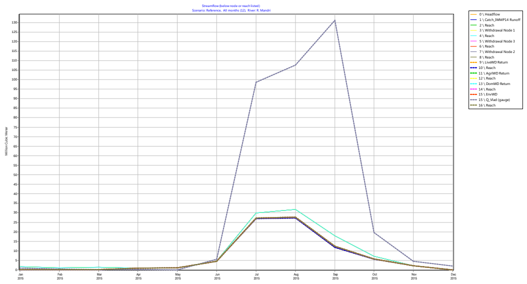
The results for IWMP 14 for the base period (2015) are given as follows:



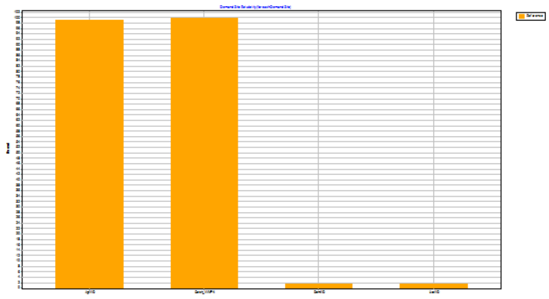
Water demand for base period (2015)



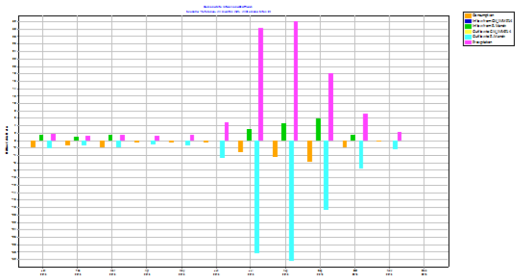
Unmet demand for the base period (2015)



Runoff generated for the base period (2015)



Reliability of demand met for the base period (2015)



Demand site inflows and outflows for base period (2015)

The above results for the reference period (2016 to 2050) are being worked out from the WEAP model

10. Research outcome from the study

Expected date of completion: 31 March 2020

11. Timeline

Sl. No.	Work Element	2018-19				2019-20			
		Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
1	Literature review								
2	Collection of hydro meteorological data, satellite images, thematic maps etc.								
3	Compilation and verification of hydro-meteorological data, baseline survey data, census data and other qualitative data								
4	Preparation of input data for WEAP model								

5	Simulation of components of hydrological processes using SWAT model								
6	Water allocation plan for different uses by scenario analysis by WEAP model								
7	Report writing								

1. Title of the Study: Rejuvenation of village ponds in identified villages of Muzaffarnagar & Meerut districts of UP

2. Study Group:

<table>
<tr><td rowspan="3">Lead Organization</td><td>Project Investigator
Dr. V. C. Goyal, Sc. G & Head, RMOD</td></tr>
<tr><td>Co-Investigators
Er. Omkar Singh, Scientist F, RMOD
Dr. Rajesh Singh, Scientist C, EHD
Er. Digambar Singh, Scientist C, RMOD</td></tr>
<tr><td>Scientific/Technical Staff
Sh. Subhash Kichlu, PRA
Sh. Rajesh Agarwal, SRA
Sh. N. R. Allaka, RA
Dr. N. G. Shrivastava, Senior Expert
Dr. Nihal Singh, Research Scientist
Dr. Kalzang Mathus, Research Associate
Sh. Sandeep Yadav, Research Associate
Sh. Subhash Vyas, Project Assistant</td></tr>
<tr><td>Civil Work Execution Agency</td><td>NPCC Limited (A GoI Enterprise), Noida</td></tr>
</table>

3. Type of Study: INCSW (MoWR, RD & GR) Sponsored Pond Project
Budget: Rs 8.3 Crores

4. Nature of Study: Applied Research

5. Date of start & duration: April 2017 (3 Years)

6. Scheduled date of completion: March 2020

7. Study Objectives:

a. Assessment of water situation in the identified villages and carry out water budgeting exercise with the respective Gram Panchayats.
b. Rejuvenation of identified village ponds through installation of appropriate Natural Treatment Systems.
c. Carry out awareness generation and capacity building of the local villagers.

8. Statement of the Problem:

Presently, ponds in the villages of western UP are in a very bad shape. Ponds are generally used as sink for all wastewater as well as for solid waste generated in the villages leading to the deposition of solid wastes and growth of weeds. Capacity of these ponds has been reduced drastically as removal of silt is not taken up on regular basis. Encroachment of the catchment area has added to the dismal state of such ponds in the rural and per-urban areas.

The project aims to develop a model for rejuvenation of village ponds, which will facilitate the practice of water conservation and management in the selected villages in totality for water security and sustainability, which is also expected to be a role model for the Gram Panchayats in other part of the UP/country.

9. Approved Action Plan/Methodology:

After field measurement of the dimensions of the ponds, DPRs were prepared for estimation of the civil works, etc. involved in the pond rejuvenation related works. Execution of the pond rejuvenation works will be carried out by awarding contract to an identified agency.

In the next phase, an appropriate NTS technology (Floating Wetland) will be established in the identified ponds for treatment of the wastewater entering into these ponds. In order to ensure effectiveness of NTS, Screen Chamber, Grit Chamber and Sedimentation chamber will be provided at the identified locations of Inlet of waste water to the pond. Side walls/embankments of the ponds will be strengthened and a small pathway will be made on the periphery of the ponds along with periphery drain to trap household waste water in order to regulate through treatment system.

10. Timeline:

S. N.	Work Element/ Milestone	2017-18				2018-19				2019-20			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
1	Data collection (baseline data of village/ community) for existing ponds and identification of suitable natural treatment system												
2	Carry out water budgeting / reuse exercise with the respective Gram Panchayats												
3	Groundwater level measurement around ponds												
4	Water/wastewater sample collection and analyses												
5	Execution of civil works (dewatering, desilting, inlet works, outlet works, floating wetland)												
6	Nursery development *(plant species for floating wetland)* at NIH, Roorkee												
7	Performance evaluation of Natural Treatment System & feasibility of treatment through Microbial inoculums												
8	Trophic State Analysis and Primary Production Capacity												
9	Capacity building, Mass Awareness & preparation of SOP for O&M of treatment system												
10	Submission of reports												

11. Achievement during last twelve months:

Objectives	**Achievements**
Rejuvenation of ponds by execution of civil works (dewatering, desilting, inlet works, outlet works, floating wetland)-through NPCC/any Govt. Agency	• The ponds for the study were identified with the help of people representatives. • MoU was signed with the gram panchayats of the ponds to be undertaken for the study. • The consent from respective gram panchayats for undertaking the research work was undertaken. • MoU was signed with NPCC Ltd., Noida for execution of civil works and awarded work of 12 ponds. • Rejuvenation work is in advance stages for all the ponds
Nursery development *(plant species for floating wetland)* at NIH, Roorkee	• The nursery for developing aquatic plant saplings has been established. • Approx. 5000 Reed Plant and 1500 Canna plant saplings has been raised and are ready for transportation to the site. • Demonstration setup for pilot scale NTS system is under progress.
Assessment of water/wastewater/ groundwater quality and sludge/soil characterization	• Water quality data analyzed, compiled and the trophic status of ponds computed for pre rejuvenation stage. • Fieldwork for collection of sludge and soil samples completed for nine ponds and the analysis of the same is under progress. • Infiltration test for the excavated pond bed carried out for nine ponds.

12. Recommendation / Suggestion:

Recommendation / Suggestion	**Action Taken**
Nil	

13. Analysis & Results:

The rejuvenation work of the ponds is under progress by the NPCC Ltd., Noida and in the meantime following activities were carried out-

a. Field investigations (Infiltration tests, sludge sampling, pond bed soil sampling, agriculture field soil sampling) were completed for 09 ponds as given below-

S.No	**Village name**	**Sludge sample**	**Soil sample**		**Infiltration Test**	**Ground Water Level Measurement**	**Ground Water Sample**	**Agri. soil sample**
			Disturbed	**Undisturbed**				
A	**MUZFFARNAGAR DISTRICT**							
1	Mohammadpur Madan-2	✔	✔	✔	✔	✔	✔	✔
2	Bhora Kalan	✔	✔	✔	✔	✔	✔	✔
3	Bhora khurd-1	✔	✔	✔	---	--		✔
4	Bhora khurd-2	✔	✔	--	✔	-	--	✔
5	Itawa-1	✔	✔	✔	✔	-	--	✔
6	Itawa-2	✔	✔	✔	✔	-	--	✔
7	Biral	✔	✔	✔	✔	-	-	✔
8	Munnawarpur Kalan	✔	✔	✔	✔	--	--	--
9	Roni Hazipur	✔	✔	✔	--	✔	✔	✔

10	Antwara	✔	✔	✔	✔	-	-	✔
B	**MEERUT**							
1	Siwaya	✔	✔	✔	✔	--	-	-
2	Pavli khas	--	--	--	--	--	--	--

Samples Collected: Following samples were collected during field investigation-

- 09 sludge samples were collected for the leachability test for trace metals and nutrients,
- 36 disturbed soil samples were collected from different depths *(i.e., D1=0-20cm, D2=20-40cm, D3=40-60cm & D4=60-80cm*) of pond soil bed for soil texture analysis, and
- 24 undisturbed soil samples were collected from different depths *(i.e., D1=0-20cm, D2=20-40cm, D3=40-60cm & D4=60-80cm*) of pond soil bed for bulk density and permeability analysis.

b. The analysis of above sludge and soil samples is under progress.
c. The final infiltration rate of the desludged pond bed was in the range of 0.4 to 13.4 mm/hr.

14. **End Users / Beneficiaries of the Study:** Villagers and Stakeholders

15. **Deliverables:** Rejuvenated village ponds, Estimated potential of fish production for the Gram Panchayats, Standard Operating Procedures (SOP) for O&M of treatment system in village ponds, Technical report(s) and publications

16. **Major items of equipment procured:** Nil

17. **Lab facilities used during the study:** Water Quality Laboratory (NIH) / IIC (IITR)

18. **Data procured or generated during the study:** Groundwater quality, Pond water Quality, Village wastewater quality, Trophic Status Index of pond, Pond productivity test, Groundwater level, Infiltration rate at pond bed, Permeability, Leachability of trace metals and nutrients in the sludge

19. **Study Benefits / Impacts:**

The outcome of the project will be beneficial for the villagers in a sense that it will increase the groundwater recharging capacity of the pond and also enhance the groundwater water quality of the area. This study will also help in replication of the technology in other village ponds of other districts of the country.

20. **Involvement of end users/beneficiaries:** Villagers & Gram Panchayats

21. **Specific linkage with Institution and /or end users / beneficiaries**: Yes

22. **Shortcoming/Difficulties:** NA

23. **Future Plan:** As per approved action plan

1. **Title of the Study:** Rejuvenation of Village Ponds in Identified Villages of Baghpat, Ghaziabad and Meerut Districts of Uttar Pradesh

2. **Study Group:**

Lead Organization	**Project Investigator** Er. Omkar Singh, Scientist F, RMOD
	Co-Investigator Dr. Rajesh Singh, Sc. C, EHD Dr. V. C. Goyal, Sc. G, RMOD Er. Digambar Singh, Sc. C, RMOD
	Scientific/Technical Staff Sh. Subhash Kichlu, PRA Sh. Rajesh Agarwal, SRA Sh. N. R. Allaka, RA Dr. N. G. Shrivastava, Senior Expert Dr. Nihal Singh, Research Scientist Dr. Kalzang Mathus, Research Associate Sh. Sandeep Yadav, Research Associate Sh. Subhash Vyas, Project Assistant
Civil Work Execution Agency	NPCC Limited (A GoI Enterprise), Noida

3. **Type of Study:** Invited study by MoWR, RD & GR,
Budget: Rs. 856.94 Lakh (Submitted for funding)

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

5. **Date of start & duration:** March 2018 (3 Years)

6. **Scheduled date of completion:** February 2021

7. **Study Objectives:**

a. Rejuvenation of identified village ponds by carrying out de-weeding, de-silting and associated civil works for development of Natural Treatment System (NTS) in the ponds for their rejuvenation.
b. Establishment of appropriate phyto-remediation based Natural Treatment System (NTS) technology for treatment of wastewater entering into these ponds,
c. Performance evaluation of the NTS based rejuvenated ponds and assessment of treated wastewater for irrigation and fishery by monitoring relevant water & wastewater quality parameters, groundwater levels, etc.
d. Capacity building and Mass Awareness Activities.

8. **Statement of the Problem:**

With the availability of millions of village ponds and local drains, there exists a vast potential of recycling and reuse of wastewater through simple retrofitting techniques. Such decentralized treatment of these small water bodies is an emerging need for their restoration and preservation, leading to multiple benefits of disaster resiliency, groundwater recharging, environment regeneration and livelihood generation at the local watershed level. The Ministry of WR, RD & GR (GoI) directed NIH to undertake the rejuvenation of ponds and wastewater treatment based on the natural solutions in 10 villages of Bagpat, Ghaziabad and Meerut.

At present, the wastewater generated from most of the villages in the country is discharged into the village ponds and leads to eutrophication of these ponds and growth of blue green algae, making the water toxic and unfit for the consumption, even by animals. Moreover, the organic laden water in the pond during recharge to the aquifer transports organics into the aquifer material enhancing the undesirable anaerobic microbial action on the aquifer media resulting in the dissolution of toxic metals like arsenic etc. into the groundwater. The polluted water resources lead to dramatic human cost. Keeping in view of the above issues related to contamination of water resources and wastewater management in the villages, the ministry directed NIH to undertake the rejuvenation of ponds and wastewater treatment based on the natural solutions in 10 villages of Bagpat, Ghaziabad and Meerut. Accordingly, the research proposal has been formulated which will address the problem related to deteriorating health of village ponds and the declining groundwater levels as well as quality in the villages of western UP on a pilot scale, the results from which can be replicated in other villages of the country.

10. Approved Action Plan/Methodology:

- Reconnaissance survey of identified village ponds for data collection along with sampling and analysis of wastewater input to the pond
- Designing and erection of suitable natural treatment system (CWT) for carbon and nutrient removal.
- Technology demonstration and performance (technical/chemical) evaluation
- Health Assessment of Water Body
- Reuse of Treated Water & Sludge
- Assessment of Methane Emission
- Hygienic and health impact assessment
- Environmental systems analysis
- Technical guidelines for design and technology application
- Training and capacity building
- Contribution to conference and publication
- Transfer of the installed treatment plants to Gram Panchayats
- Submission of final report

11. Timeline:

Sr. No.	Activities	YEAR 1				YEAR 2			
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
1	Identification of study site								
2	Site survey, sampling and analysis of samples								
3	Detailed engineering design								
4	Construction of CW based treatment plants								
5	System optimization								
6	Technology demonstration and performance evaluation								
7	Assessment of methane emission								
8	Health Assessment of Water Body								
9	Reuse of Treated Water & Sludge								
10	Hygienic and health impact assessment								
11	Environmental systems analysis								
12	Guidelines for design and technology application								
13	Training & capacity building								
14	Participation of Gram Panchayat								
15	Transfer to Gram Panchayats								
16	Contribution to conference and publication								
17	Final technical report								

HARD ROCK REGIONAL CENTRE BELAGAVI

Scientific Manpower

S N	Name	Designation
1	Dr.B.Venkatesh	Scientist F & Head
2	Dr.B.K.Purandara	Scientist F
3	Dr.M K Jose	Scientist E
4	Dr.Chandra Mohan T.	Scientist D
5	Dr.N. Varadarajan	PRA
6	Mr.Chandrakumar S	SRA

Work Programme 2018-19

SN	Title of Project/Study	Study Team	Duration	Funding
INTERNAL STUDIES				
1	Assessment of Water Resources in Ungauged Catchments of West Flowing Rivers of Karnataka	CMT(PI) & Sc. HRRC	3 years (4/17-3/20)	NIH
2	Climate Change Impact assessment for Jayakwadi Reservoir	BV (PI), and officers from WRD, Govt. Maharashtra)	3 years (01/18-3/21)	NIH
3	Analysis of Spatio-temporal Characteristics of Sediment Carrying Capacity of Rivers of Karnataka State	M K J (PI)	2 Years (4/2018- 3/'20)	NIH
SPONOSRED PROJECTS				
4	Clean and safe drinking water supply to rural community using river bank filtration techniques in hard rock regions of Krishna basin, Karnataka, India.	BKP (PI) & SK	Apr 2016 – Mar 2019	DST
5	Studies on Occurrence, Distribution and Sustainability of Natural Springs for Rural Water Supply in parts of Western Ghats, India	BKP (PI) & Sc. HRRC,	3 years (4/17-3/20)	NHP
6	Hydrological evaluation of existing water conservation/ harvesting structures in selected watersheds of Amravathi and Ahmed Nagar districts, Maharashtra state	CMT (PI)	1 year (10/17-10/18)	DoLR (under NNWP)
7	Water Balance Studies in selected Watersheds of Nalgonda and Mehaboob Nagar Districts of Telangana	M K J (PI)	1 year (10/17-10/18)	DoLR (under NNWP)
8	Impact of Land use/Land cover Changes on Ground water – A Case Study (*submitted for sponsorship from MoES, and is approve in principal and sanction letter awaited*)	BKP & BV	3 years (April 16-March 19)	MoES
CONSULTANCY				
9	Flood Review in Kali and Sharavathy river basin, Dam Break analysis, inundation mapping and preparation of Emergency Action Plan for Dams in Kali, Sharavathi and Varahi river basin	BV (PI)	2 years	Karnataka Power Corporation Limited, Govt. of Karnataka

1. Progress of ongoing studies for 2018-19.

Title of study : Impact of LU/LC and catchment characteristics on Runoff and Groundwater Dynamics of Western Ghats, Karnataka

- **a) Study group:** B.K. Purandara, B. Venkatesh, Sharad kumar Jain and C. P. Kumar
- **b) Type of study:** MoES sponsored
- **c) Date of start and duration: 2018**
- **d) Scheduled date of completion: 2021**
- **e) Objectives:**
    - to investigate the influence of catchment characteristics - physiographic and climatic, on the dynamics of runoff and groundwater and establish the major controls in a region where Horton's overland flow is only a minor component of stream runoff;
    - to quantify hydrologic responses such as rainfall-runoff and evapo-transpiration under different forest covers/land covers (natural forest, degraded land and acacia plantation) at larger spatial and temporal scales including the impact of forestry on peakflows and baseflows.
    - to understand the effects of evapotranspiration on baseflow to changes in forest landscapes and interacting responses (surface and groundwater) to forest management and disturbance.
    - to quantify the infiltration capacity and saturated hydraulic conductivity under different land covers which will give an account of the impact of afforestation and deforestation on soil hydrologic regimes. This will help in understanding the role of preferential flow path-ways in ground water movement and recharge characteristics
    - to estimate the groundwater recharge under different land use/land covers using conventional techniques (based on field and laboratory investigations carried out during the study period).
    - to assess the association between forest cover/land use and the groundwater system quantitatively and in a spatially distributed manner using MODFLOW to "scale up" findings from small spatial and short time scales to larger spatial and longer time scales
- **f) Study area:**
  The current study is aimed to understand the impact of land-use changes on flow under three rainfall regimes namely, Coastal and Mid-ghat zones. To actualise this, five watersheds were selected in Uttara Kannada District, Karnataka, 3 watersheds, one each under homogenous land covers of *Acacia auriculiformis* plantation (AaP) (7 ha), Degraded forest (DF-C) (7 ha) and Natural forest (NF-C) (23 ha) lies in Biligi watershed of Siddapur taluk, Areangadi village of Honnavar taluka and Barchi watershed in Barchi village of Haliyal/Supa taluka.
- **g) Methodology**
    - Establishment of Observation network for rainfall, evaporation, discharge and other hydrological parameters in selected watersheds of Uttara Kannada and Kodagu/ Hassan districts.
    - Ground water level monitoring and installation of piezometers under different land covers
    - Soil Moisture monitoring using moisture probes and estimation of ET using the soil moisture data,
    - In-situ determination of soil hydraulic parameters and determination aquifer parameters across an array of climatic regions within North Kanara district,
    - Laboratory analysis of soil for determining soil moisture availability and soil moisture retention characteristics,
    - Surface and ground water balance estimates of selected watersheds
    - Base-flow estimation
    - Numerical modeling using SWAT and MODFLOW to assess the impact of forest cover/land use changes on ground water resources
- **h) Approved / Proposed work plan: Funded by MoES, Govt. of India**
- **i) Progress:**
  Land Use and Land Cover (LULC) changes in Uttar Kannada district during 2001 to 2015 were analysed using remote sensing data with geographic information system (GIS). The basic objective of the present observation is to quantify the LULC in three different hydrological

regimes of the study area. The ancillary data in the form of topographic maps and Google Earth were used to create the base maps of the region. Based on Land use/Land cover, the study area was classified into number of categories, viz. Evergreen forest, moist deciduous forest, Dry deciduous forest, Scrub forest/Grassland, Forest plantations, Built up, Water, Crop land, Horticultural plantations and Open land. The land use analysis reveal a decline in evergreen forests from 55% (2001) to 30% (2015) with an increase of crop land (10% to 14%) and built up (less than 1% to 3.5%). Land use change analysis showed the spurt in rate of decline of the evergreen to semi evergreen forests by about 0.5%. The maximum rate of fluctuation was observed in evergreen forest followed by moist and dry deciduous forest and Rivers/ streams/ reservoir. The rate of decrease in evergreen forest/ semi-evergreen is 0.71%. Similarly, the rate of decrease in River/ streams/ reservoir is 0.56%. But, moist and dry deciduous forest, degraded forest plantation and scrub forest 0.57%, 0.30%, 0.29% and 0.16% respectively during 2015. Increase in the rate of land use change was observed with increase of towns (6.05%/year). With respect to agriculture plantation and cropland, decreasing trend was observed in tree plantation.

Among various hydrological components, soil moisture and hydraulic properties are the two important factors which significantly influence vegetation density and soil moisture characteristics. Therefore, a clear knowledge of soil moisture pattern and hydraulic properties associated with tree density across various land use system is essential. Hence, a study was conducted in Areangadi region of Honnavara taluk (Uttara kannada, Karnataka) to understand the soil moisture profile and hydraulic properties under various land use/land covers with particular reference to vegetation density. Vegetation density per hectare was highest in natural forest and this was reduced up to 50.11 and 50.55 percent in *Acacia auriculiformis (Acacia)* plantation and 88 and 89 percent in degraded forest during 2009-10 and 2010-15 respectively. Soil moisture variation across various soil depths under different land use system shows that there is an increase in moisture contents both in acacia plantation and degraded forests, whereas in the natural forests, it shows a decline up to a depth of 90 cm and an increase further down (to a depth of 150 cm). It is also noticed that, beyond 190 cm depth, soil moisture in all three land covers remained relatively stable. The study revealed that the variation in soil moisture content depends not only on rainfall pattern and intensity, but also on the tree species and density. Among various land use system, average soil moisture was highest (22%) in natural forest followed by acacia plantation (20%) and degraded forest (19%). Saturated hydraulic conductivity (Ks) with depth is decreasing from surface to 1.5 m in all three land covers (Forest, Acacia plantation and degraded forest). However, it is observed that, particularly in forest and plantations there are instances of high rate of hydraulic conductivity at the surface layer, followed by considerable reduction up to 0.45 m depth and become steady thereafter. Further, the present study illustrates that vegetation density has considerable impact on soil hydraulic properties (Ks) and found positively correlated with type of vegetation. Average soil hydraulic property (Ks) was found highest (119 mm/hr) in natural forest followed by acacia plantation (75 mm/hr) and minimum of 18.39 mm/hr was observed in degraded forest.

Title of study : Studies on Occurrence, Distribution and Sustainability of Natural Springs for Rural Water Supply in parts of Western Ghats, India

a) **Study group:** Dr. B.K. Purandara and Scientists of Regional Centre
b) **Type of study:** PDS under NHP
c) **Date of start and duration:** Oct' 2017
d) **Scheduled date of completion:** 2020
e) **Objectives:**
   - To evaluate the impact of changes on physiography, climate parameters such as rainfall, evaporation, land use/land cover changes on hydrological regimes in selected watersheds in parts of Western ghat region
   - To understand the role of unsaturated soil zone on hydrological responses of watersheds based on soil hydrological characteristics and monitoring of soil moisture variation during the study period
   - To develop a watershed model, which would help to quantify both streamflow and baseflow.
   - Estimation of interflow in the selected catchments using field and analytical methods
   - Estimation of recharge rates in the selected watersheds using spring flow, rainfall and Temperature data
   - To evaluate the sustainability of the springs in the changing scenario of land use/land covers and its (spring water) role in rural water supply schemes
   - Assessment of water quality of spring water, groundwater and surface water
   - Application of isotope techniques to understand the origin of springs and its source
   - Socio-economic impact caused due to change in spring water flow and land use/land cover changes

f) **Study area:** Western Ghats region of Karnataka and Maharashtra

g) **Methodology:**
   1. Hydrogeological investigations
   2. Geomorphological analysis of the study area using ARCGIS
   3. Determination of soil hydrological parameters using disc permeameter in Malaprabha and Ghataprabha catchment including parts of Sindhudrug district
   4. Application of SWAT model to Malaprabha and Ghataprabha catchment

Progress of the study

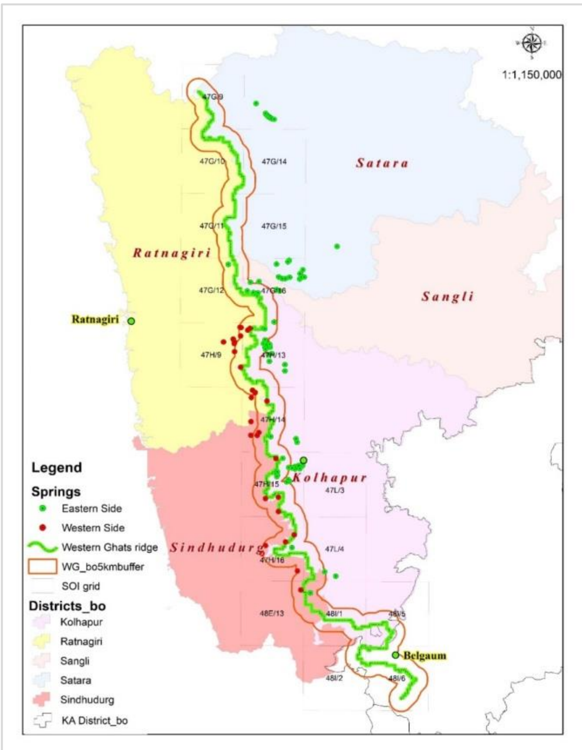
1. Inventory on springs in the buffer zone of Western Ghats from Satara (North) to Belgaum (South).
2. Around 232 springs explored for feasibility of observations and local support.
   - Sindudurg - 18
   - Ratnagiri - 49
   - Satara and Sangli - 64
   - Kolhapur – 70
   - Belgaum – 32
3. Collection of water samples and physic-chemical analysis of typical spring water of Western Ghats region
4. Soil profile investigations of the spring zones identified in Western ghat region
5. Estimation of Soil hydraulic properties such as infiltration, hydraulic conductivity and soil moisture characteristics
6. Isotopic studies have been done to understand the source of spring water
7. SWAT model was applied for Malaprabha, Ghataprasbha and watersheds in Sindhudurg district
8. Preparation of soil, land use land cover and geology map of the study by using secondary data

9. Estimation of Groundwater Recharge using both empirical methods and HYDRUS-1D model
10. Population statistics and beneficiary villages depending on under springs for all the districts related to the study is collected.
11. Geotagging springs with attribute information to create a spatial geodatabase on spring occurrences.

Some of the Springs identified for detailed investigations

h) Progress

Sl no	Station	Lat	Long
1	Chandghad	15° 30' 11.16"	78° 5' 1.68"
2	Alewadi	17° 47' 20.76"	73° 52' 21.72"
3	Dhangarwadi	17° 47' 30.91"	73° 51' 41.44"
4	Dhangarwadi (Top hill)	17° 47' 20.76"	73° 52' 21.72"
5	Ambegar	17° 51' 1.01"	73° 47' 57.48"
6	Kamargaon	17° 17' 52.3"	74° 7' 41.74"
7	Pal village	16° 17' 39.44"	74° 9' 59.29"
8	Gargoti	16° 18' 29.88"	74° 10' 15.96"
9	Amboli	15° 57' 17.86"	74° 1' 39.43"
10	Amboli	15° 57' 57.6"	73° 59' 24"
11	Ringewadi	16° 34' 2.32"	73° 45' 52.85"
12	Gotwewadi	16° 2' 2.04"	73° 58' 32.16"
13	Gotwewadi	16° 2' 29.15"	73° 58' 35.58"
14	Kundi	17° 6' 33.8"	73° 41' 29.62"
15	Kundi	17° 6' 34.16"	73° 42' 30.64"
16	Rajapurganga	16° 38' 45.17"	73° 32' 17.48"
17	Vanjole	17° 2' 6.36"	73° 40' 18.84"
18	Vanjole	17° 2' 16.44"	73° 40' 33.96"



Location of identified study site in Western Ghats

	
Date of visit: 24-Nov-2018	
Location: Latitude : 16° 18' 29.88" Longitude : 74° 10' 15.96" Elevation : 723m	Toposheet no : 47/L/3 State : Maharashtra District : Kolhapur Tahsil / Taluk : Gargoti Village : Ghat Section
Data Collection:	**Data collected:** • Geological inspection • Hydrology – discharge measurements • Socio economic details
Socio – economic interaction	**Socio economic details** • Spring is perennial • Used for agricultural and domestic purpose • Alternative source of drinking water is dug-wells

Water Quality status:

pH	7.1	
EC	13.06	µs/cm
TDS	28.1	mg/l
Acidity	4	mg/l
Alkalinity	80	mg/l
TH	46	mg/l
CH	36	mg/l
MH	10	mg/l
Chloride	22	mg/l
Na	7.61	mg/l
K	0.27	mg/l
Turbidity	0.21	NTU

Title of study: Assessment of Water Resources in Ungauged Catchments of West Flowing Rivers of Karnataka

a) Study group: Chandramohan T., B. Venkatesh, M. K. Jose and Purandara B.K.
b) Type of study: Internally funded
c) Date of start and duration: 3 years (2018)
d) Scheduled date of completion: 2021
e) Objectives:
- Evolving methodology for the estimation of potential water availability from River basins of Western Ghat region by developing relationships between flow and catchment characteristics

f) Study area: Selected river basins of Western Ghats, from Kerala Karnataka and Goa
g) Methodology:
- identify catchment characteristics that can be used for predicting flow characteristics of ungauged catchments.
- examine the feasibility of using catchment characteristics for identifying catchments with similar hydrological responses or delimiting hydrologically homogenous regions.
- identify suitable flow characteristics, which can be used to develop multiple regression relationships for prediction in ungauged basins.
- develop appropriate relationships between the selected flow characteristics and catchment characteristics for available gauged streams and transferring such relationships to ungauged basins.
- test the possibility for regionalizing parameters of selected rainfall-runoff models (such as SWAT) on the basis of catchment characteristics, and using these to estimate flow characteristics of ungauged catchments.

h) Progress achieved:
- Catchments with data availability were identified: 17 from Kerala and 22 from Karnataka (list of gauge sites are given in the tables)
- Flow and Rainfall data of the catchments from Kerala and Karnataka are collected
- Catchment characteristics selected are: Catchment area; Drainage density; Slope Proportions of the catchment; Proportions of the catchment with different land cover types; Mean of monthly and annual rainfall; Average number of rainy days per year; Maximum, average, and minimum catchment elevation; Mean of monthly and annual potential evaporation; Normalized difference vegetation index *(NDVI),* etc.
- Flow characteristics identified are: Mean annual runoff, Base flow index, Average number of days per year with no flow, Flow duration curves, Distribution of mean annual runoff into monthly flows, etc.

Karnataka

Sl No	Gauge Site	River	C A (Km^2)
1	Barchi	Barchi nala (Kali)	15
2	Kamadhenu Weir	Bhadthi nala (Kali)	372
3	Chapoli	Mahadayi	124.4
4	Dasanakate	Dasanakatte (Varahi)	135
5	Taregoan Bridge	Dusginala (Kali)	502.9
6	Sarve Bridge	Gowrihole	126
7	Polali	Gurupur	688
8	Haladi	Varahi	505
9	Halkal	Halkathole (Kollur)	108
10	Jadkal	Jadkahole (Kollur)	90
11	Kadumanehalla	Kadimane (Nethavathi)	5.4
12	Kakkattuhole Bridge	Kakkattuhole (Barapole)	98
13	Kateel	Kalluhole	78
14	Nadagundi Bridge	Konganahole (Barapole)	83

15	Mani	Varahi	163.2
16	Sanur	Mulki	30
17	Pane Mangalore	Nethavathi	3187
18	Kokkarne	Sitanadi	343
19	Uppinangadi	Kumaradhara (Nethravathi)	-
20	Uppinangadi	Nethravathi	1095
21	Varahi	Varahi	163.2
22	Harle Estate	Yettinahole (Nethravathi)	28

Kerala

Sl No.	**River**	**Gauge Site**	**CA (Km^2)**
1	Vamanapuram	Ayilam	540
2	Valapatanam	Perumannu	1070
3	Pulanthode	Pulamanthole	790
4	Periyar	Neeleeswaram	4234
5	Payaswini	Erinjipuzha	957
6	Muvattupuzha	Ramamangalam	1208
7	Meenachil	Kidangoor	615
8	Manimala	Kallooppara	731
9	Pamba	Malakkara	1713
10	Kallada	Pattazhy	1210
11	Kaliyar	Kalampore	405
12	Kadalundi	Karathode	750
13	Chalakkudy	Arangilay	1342
14	Chaliyar	Kuniyil	1876
15	Bharathapuzha	Kumbidi	5755
16	Bharathapuzha	Ambalapalayam	950
17	Achankoil	Thumpamon	810

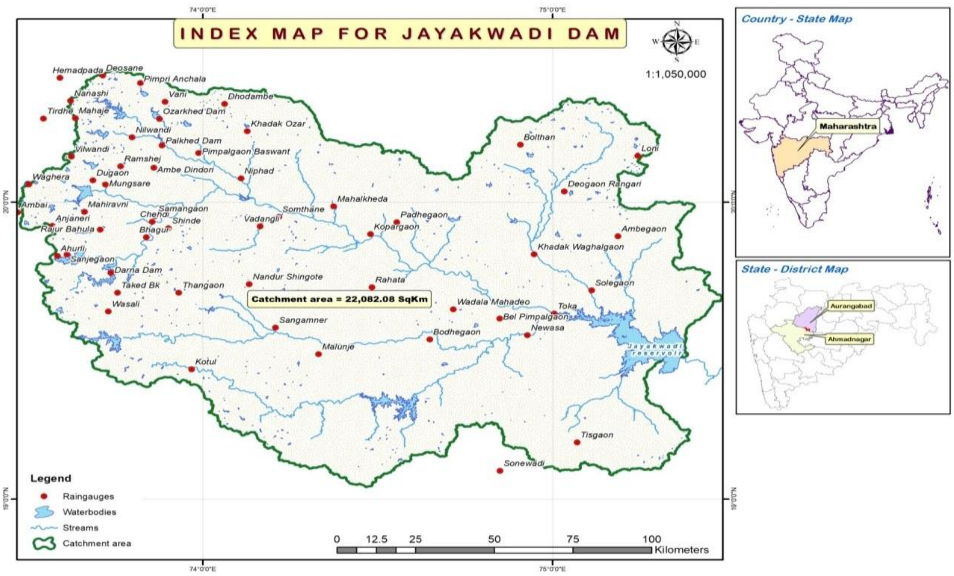
Title of study: Climate Change Impact Assessment for Jayakwadi Project

a) **Study group:** Dr. B. Venkatesh, Scientist of RC and Officials from WRD, Govt. of Maharashtra
b) **Type of study:** Internally funded
c) **Date of start and duration:** 3 years (April 2018)
d) **Scheduled date of completion:** 2021
e) **Objectives:**

- Evaluate the possible change in water availability and extreme hydrological events due to climate change upto yr. 2100 in Jayakwadi catchment using a river basin hydrological model.
- Assessment of influence of anthropogenic intervention (construction of small and medium irrigation structure and diversion weirs) on water availability at various project in the Jayakwadi catchment

f) **Study area: Jayakwadi river catchment in Maharashtra**

The Godavari basin is the second largest river basin of India (30.2 million ha) and partly covers six states viz., Maharashtra, Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Odisha, and Karnataka. About 49% of Maharashtra's geographical area (15.26 million ha) comes under Godavari basin. In Maharashtra, the Godavari basin is divided into 27 sub-basins. The Upper Godavari sub-basin has a geographical area of 2.2 million ha and about 8.6 million population lives in 45 towns and 1883 villages. The sub-basin comprises the entire catchment of the Godavari river from its source to Jayakwadi dam including the catchment areas of the rivers Mula, Pravara and all other tributaries which joins the Godavari river in this reach. There are 17 major, 14 medium, and 558 small irrigation projects in the sub-basin with design live storage capacity of 193.5 TMC. The location of Jayakwadi basin is shown in **Figure**.



Study area map

g) **Methodology:**

- The investigation shall be carried out to detect the climate change signals in the present climate based on the historical datasets of precipitation, temperature and other climate datasets, land use, soil and topographical data;
- A physically based distributed/semi-distributed hydrological model shall be setup for the study area based on the data availability and the objectives of the study and the model shall be

calibrated and validated to understand the hydrology of the basin and the interaction between the various components of the water balance under the present climatic conditions;

- Based on the global projections through General Circulation Models/Regional Climate models, the climate change induced impact assessment studies on the water resources sector shall be carried out under alternate future emission scenarios. The impact assessment studies will help to understand the scenario of water availability as well as extreme events like floods and drought into the future time horizons;
- The anthropogenic intervention will be introduced into the model in the form of reservoirs and their date of operation to evaluate the actual setup at present and for the future scenarios.

h) Progress of the study

Data Availability

The Water Resources Department, Govt. of Maharashtra, Nashik has been monitoring and maintain a good the hydro-meteorological network in the basin. The data pertaining to this study was provided by the WRD, Nashik after validating the data using the HYMOS software. The data collected are; (i) Rainfall; (ii) Temperature; and (iii) Discharge.

Rainfall Data : There are more than 100 raingagues are installed and are being used for measurement of rainfall in the catchment. However, few stations have less than 10 years of data which are not considered for the analysis. The stations which were considered for analysis are shown in Figure above.

Results :

The collected rainfall data has been analysed for (i) Trend Analysis; (ii) Change point analysis; (iii) Drought Analysis; (iv) Processing of the CORDEX Data for the study area and (v) Persistence of Drought using Hurst Coefficient. The results are shown below in the form of Figure

Trend Analysis of the rainfall show that, the rainfall amounts are decreasing during the monsoon in many part of the basin specifically in the head water part of the catchment. However, the central part of the catchment records the increasing trend as depicted in Figure (Annual time scale). Further, it is noticed that, stations which are located within the head water region show that the mean rainfall in considerably decreasing after 2000 (the data considered for analysis is form 1970 to 2016). Similar analysis has been carried out for all the monsoon months and recorded the more or less the same trend in all these months.

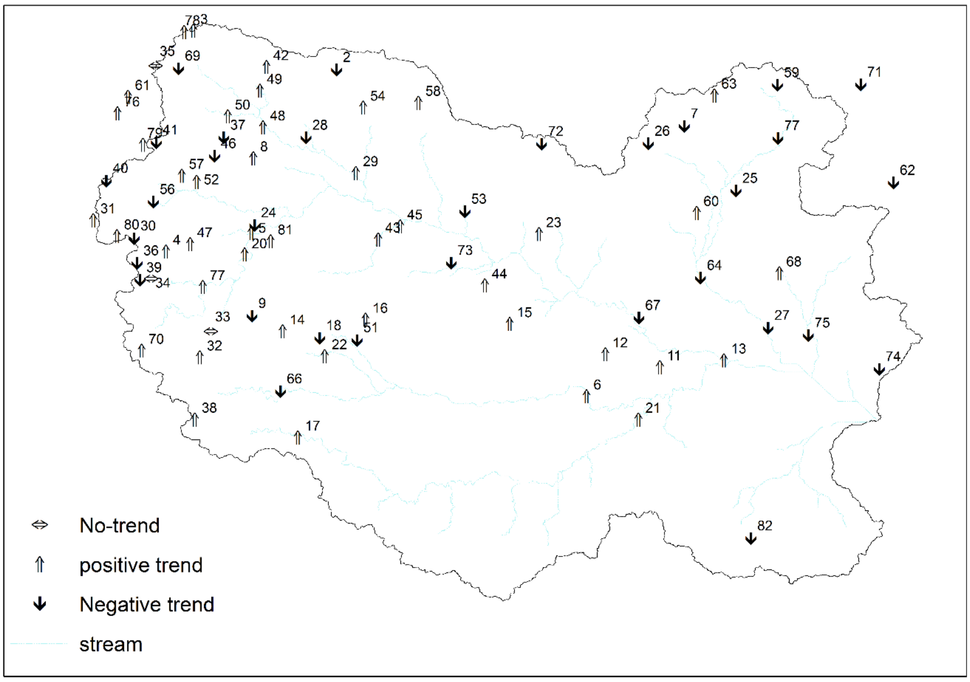


Figure * : Trend of Annual Rainfall in the study area

The drought analysis on the annual time scale was carried out using the method described by Ponce et al., (2000). The persistence of the drought in the study area was computed using the Hurst coefficient. The values of Hurst coefficient is greater than 0.5 indicates the persistence of the drought. The spatial variation of the Hurst coefficient is depicted in Figure below and indicate clearly the central part of the basin is with the higher Hurst coefficient, which indicate the persistence of the drought.

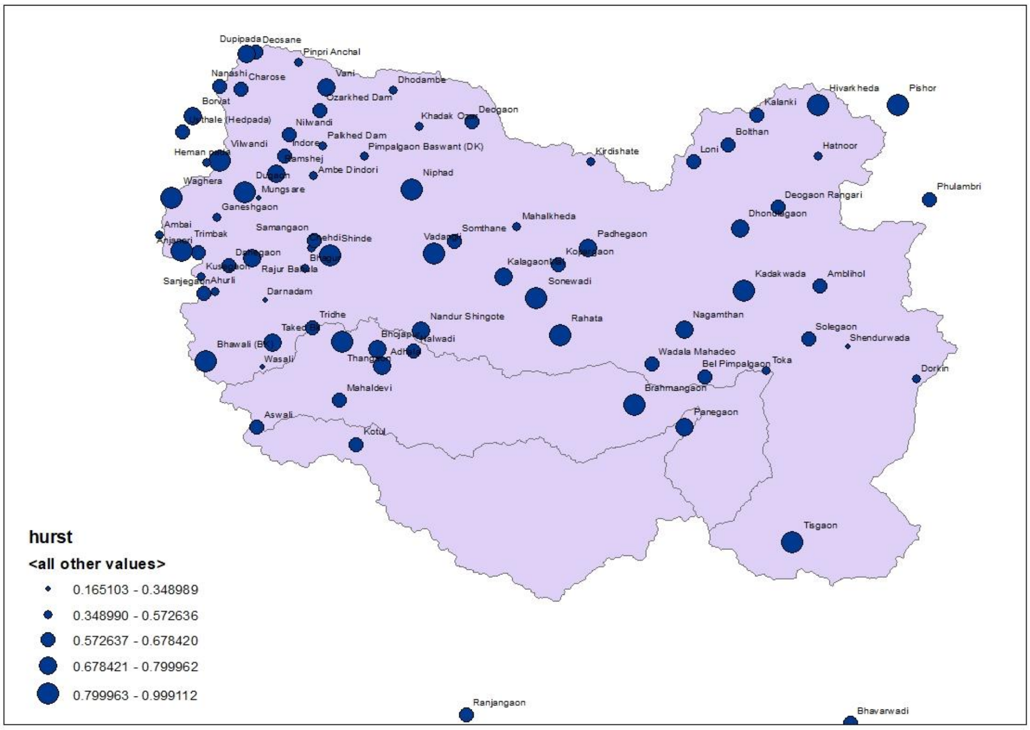


Figure * : Spatial variation of Hurst Coefficient to depict the drought persistence in the study area

2. List of completed studies during 2018-19.

Title of Study: Clean and safe Drinking Water supply to rural community using River Bank Filtration technique in Hard Rock Regions of Krishna Basin, Karnataka, India"

a) Study group: Dr. Purandara and Dr. Sudhir Kuamr
b) Type of study: DST Sponsored
c) Date of start and duration: 3 Year (April 2016)
d) Scheduled date of completion: 2019
e) Objectives:

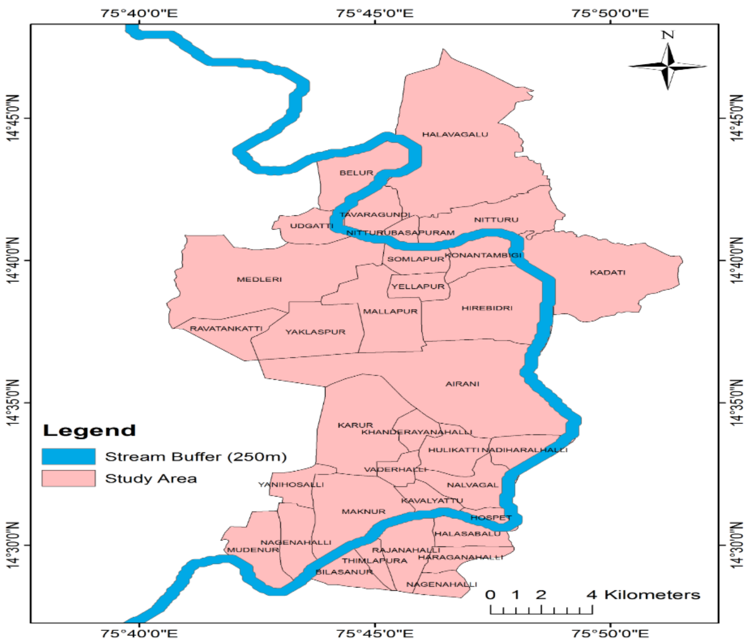
- to carryout detailed hydrogeological and hydrological investigations along the bank of Tungabhadra river, Karnataka
- to install RBF wells for accessing clean and safe drinking water from low quality river water by the rural community.
- to conduct aquifer performance of RBF wells for suitable production of high-quality water
- to carry out aquifer performance of selected wells (existing) in the study area to understand the impact of RBF wells (tests will be conducted before and after the installation of RBF)
- Groundwater and surface water quality monitoring to develop a baseline information on water quality to compare with RBF water quality
- to understand the extent of removal of physical, chemical and biological contaminants through simple low cost RBF technology.
- Modelling of surface and groundwater interaction to understand the impact of river flow and pumping
- to test the acceptance of the RBF system and assess possible changes in the health and economic status of the villagers in the study area.
- To organize awareness programs to transfer the state of art technology of RBF to other parts of Karnataka.

f) Study area:
Villages in the riparian areas of Tungabhadra river covering parts of Davangere and Shimoga districts

g) Methodology:

1. Identification and selection of potential RBF sites.
2. Detailed topographical and hydrogeological investigation of the selected site (alluvial aquifer and river body).
3. Identification and evaluation of nearby ground water resource.
4. Selection of site specific extraction well and its operational aspects for proper filtration.
5. Construction of extraction well/production well and water quality analysis of the bank filtrate.

h) Approved / Proposed work plan: Approved by DST, New Delhi (Sponsoring agency)



Study Area

i) Progress:

- Surface and ground water quality analysis in the vicinity of RBF
- to understand the extent of removal of physical, chemical and biological contaminants through simple low cost RBF technology
- Water usage and health impact survey
- Modelling of surface and groundwater interaction to understand the impact of river
- flow and pumping

An overview of River Tungabhadra **Installation of RBF Wells**

Visit of Students from USA to RBF Training of under graduate students on RBF Sites Technology

j) Analysis and results

Riverbank filtration (RBF) systems were installed in rural villages along a 18 km stretch in parts of Tungabhadra River in Ranebennur taluk of Davanagere district of Karnataka which is designed to supply approximately 2000 people. Site selection criteria included hydrogeological suitability, land availability and access, proximity to villages and their population sizes, and electric power supply. Water samples were collected from the river and the RBF wells over more than one year (November 2016 to April 2019) and were analyzed for *E coli, F- Coli, Pseudomona etc*. The shallow groundwater at the study sites was also sampled, but less frequently. The hydrogeology of the four RBF systems was described in terms of bore-log data, mixing of river and groundwater, pumping test data, and vertical water column profiling. *E. coli* removal percentages of >99.9% were observed immediately before and during the monsoon, when *E. coli* concentrations in the river were the highest. The results provide evidence that RBF installations are challenging but possible under the climate and hydrogeologic conditions prevailing in this part of southern India. Specifically, when installing RBF wells in the study area, one needs to balance the well depth and distance from the river against the limited extent of hydraulic connection. Water quality modeling of a stretch of the study area indicated that the self purification capacity of the river is very high. The study also revealed that the extent of removal of major anions and cations depends mainly on the hydraulic properties of the aquifer. The viability of RBF systems as a domestic water source is also influenced by other factors that are not limited to southern India, including surface water and groundwater salinity, agricultural practices surrounding RBF wells, and the reliability of the power grid.

k) Outcome / deliverables:

1. Clean and safe drinking water supply to the selected villages
2. Surface and ground water quality characteristics in parts of Tungabhadra river basin
3. Sustainability of ground water availability for water supply
4. Extent of removal of chemical contaminants from the river water drawn through RBF wells

Title of Study: Status Report on Rejuvenation of Vrishabhavathi River in Bengaluru

a) **Study group:** Dr. B. Venkatesh, R. Abhilash and Scientist of RC
b) **Type of study:** Internally funded
c) **Date of start and duration:** 1 years (April 2018)
d) **Scheduled date of completion:** 2019
e) **Objectives: (i)** Prepare a status report on Vrishabavathi river based on various analysis of secondary data obtained from line departments concerned with the Vrishabavathi study area.

f) Study Area

The Vrishabhavathi catchment is located in the state of Karnataka. The rishabhavathi River originates in Bengaluru district and flows through Ramnagara district as a part of sub-tributary of Arkavathi River which is one of the major tributaries to River Cauvery. The Catchment of river Vrishabhavathi is spread across three Taluks of Bengaluru and Ramanagara Districts viz., Bengaluru North 27.7%, Bengaluru South 58.4% and Ramnagar Taluk 13.9%.

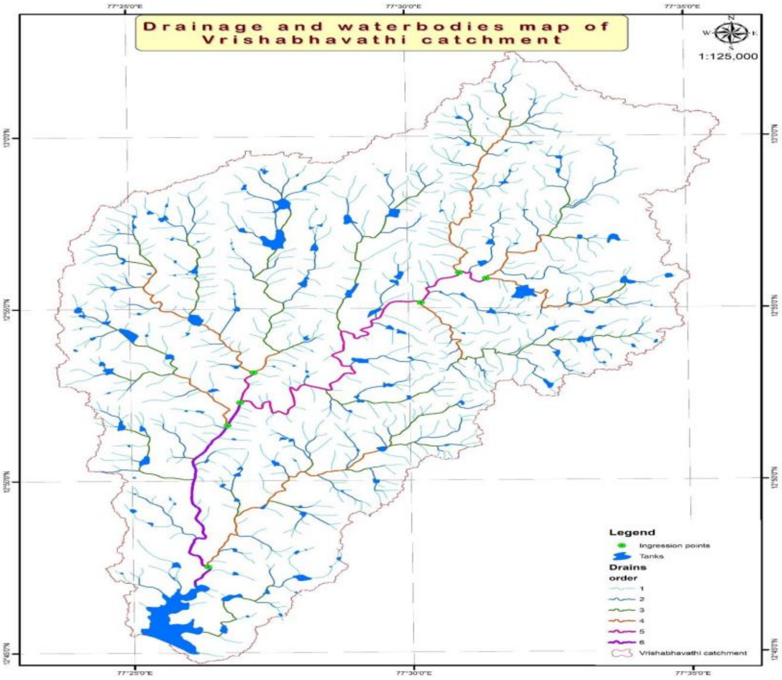


Figure **: Location of Water Bodies along the river

g) Methodology: The following methodologies were used in the present study;

1. River Morphology
2. Land use Change in the catchment
3. Water Quality Analysis
4. Hydrology of Vrishabhavarhi river

Progress :

Land Use change in the Catchment : To assess the changes in Built-up area for the Vrishabavathi catchment cloud free satellite imagery of LANDSAT8 and LISS III was used and supervised classification was carried out. The Classification was carried out for 4 major classes viz., Built-up area, Vegetation cover, Open land, Waterbodies.

The supervised classification indicates that the Built-up area in the Vrishabavathi catchment has increased from 31% to 42% during 2008 and 2019. The vegetation cover is observed to be decreasing and hence the area of water bodies has also decreased.

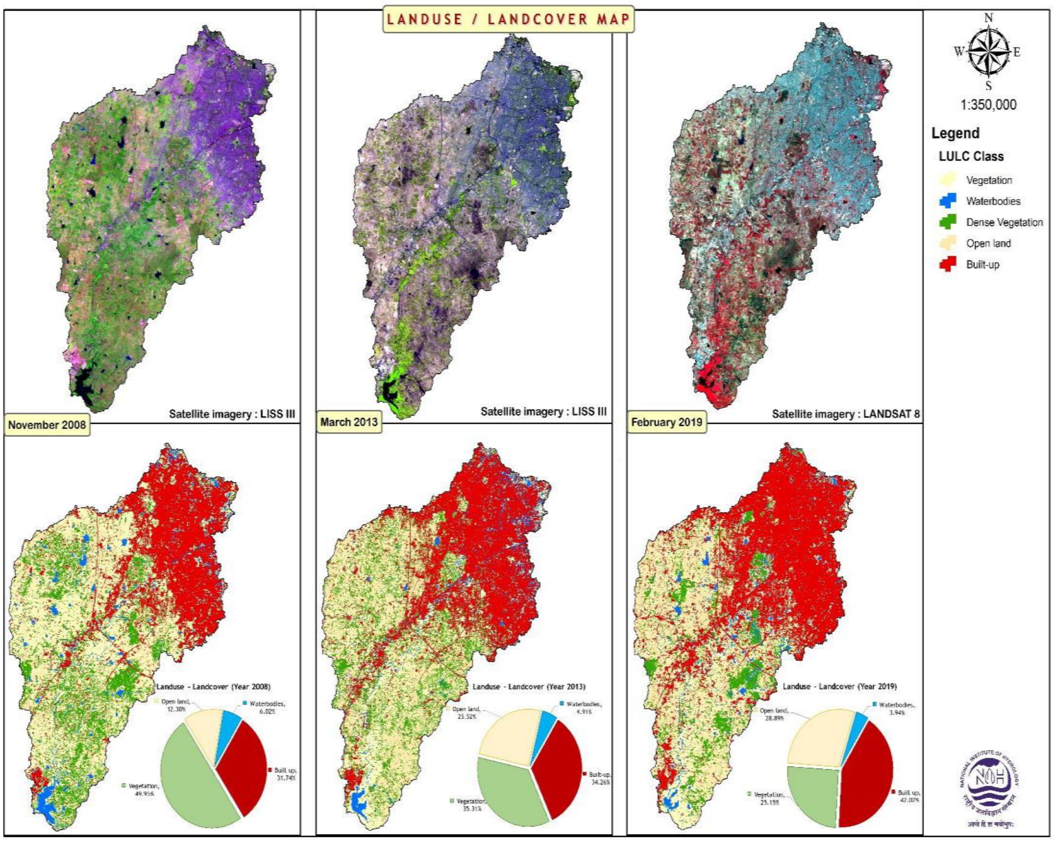


Figure *: Land use changes in the Catchment for a period 2008 to 2019

Status of Surface Water Quality : From the surface water quality analysed in 48 lakes in and around Vrishabavathi catchment, it is found that 42 lakes are polluted having water quality category of Class E. 4 lakes are under the category of Class D and only 2 lakes are in the category of Class C which is Sankey Tank and Lalbagh Lake. The Water quality Index (WQI) for lakes in category Class D and E are Unsatisfactory whereas the two lakes having water quality category Class C is having satisfactory WQI.

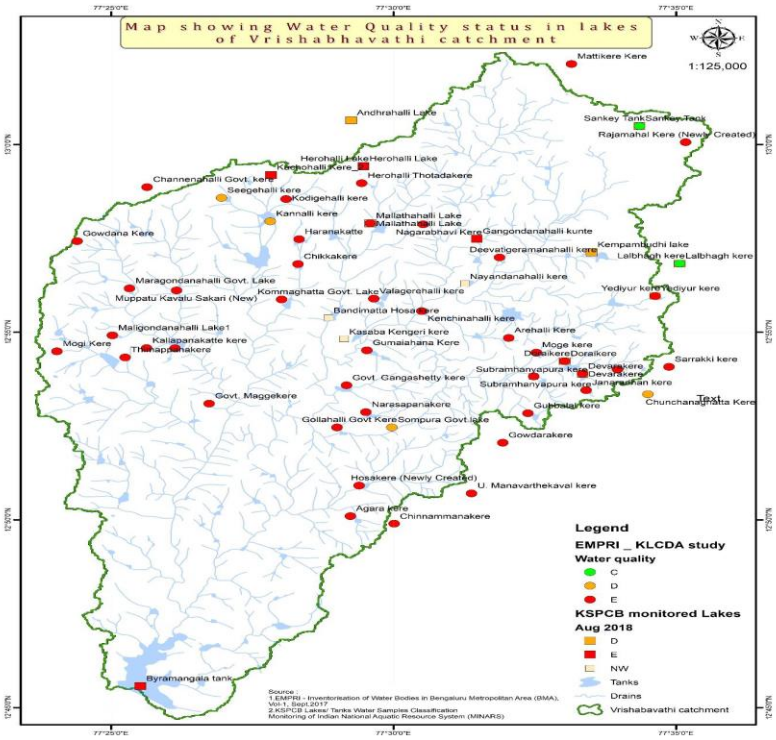


Figure * : Status of Water Quality in Basin

Spatial and Temporal Variation of In-stream Water Quality : The water quality of Vrishabavathi water has exceeding concentration levels of BOD, COD, TDS, NH3-N and nil DO. It can also be observed that there is gradual increase in TDS and EC during the course of river which may be linked to presence of industrial effluents in the valley. There is also presence of Oil and Grease in the valley. The concentrations of TSS, BOD and COD gradually decreases as a process of self-purification but still exceeds the permissible limits (BOD<3mg/l) criteria for reviving rivers as healthy river.

It is reported that there are dyeing & washing units, washing units, Electroplating units, Vehicle service stations, and plastic recycling units in the Vrishabavathi catchment resulting in disposal of solid wastes, oil and grease, C&D wastes, untreated wastewater

h) Outcome:

- Morphometric characteristics of the Vrishabavathi catchment indicates that the catchment is elongated and has extended peak with low yields.
- The catchment area is predominantly gentle slope.
- The catchment has considerable regions of Shallow weathered pediplain and Valley fill zones where groundwater prospects is expected to be good.
- Due to geomorphological conditions the groundwater aquifers are vulnerable to pollution from the Surface waterbodies.
- Landuse/ Landcover change detection analysis for years 2008 - 2019 indicates that 42% of the catchment is urbanized and expanding rapidly at uncontrollable rate.
- The impact of urbanization has impacted nearly 60% of the waterbodies in the catchment which is in disused state.
- g) Surface water sources are highly polluted due to sewage discharges from the city.
- Pollution status of Vrishabavathi river is alarming and very difficult to account the effluent discharges.
- Undisturbed independent non-urbanized catchments contributing to
- Vrishabavathi river can be made use to harvest less polluted water.
- Surface water harvesting from independent catchment can be utilized to recharge groundwater aquifers to prevent irreparable pollution status of aquifers.
- Existing Waterbodies and streams in the peri-urban and rural catchments of Vrishabavathi

can be rejuvenated to harvest unpolluted rainwater.

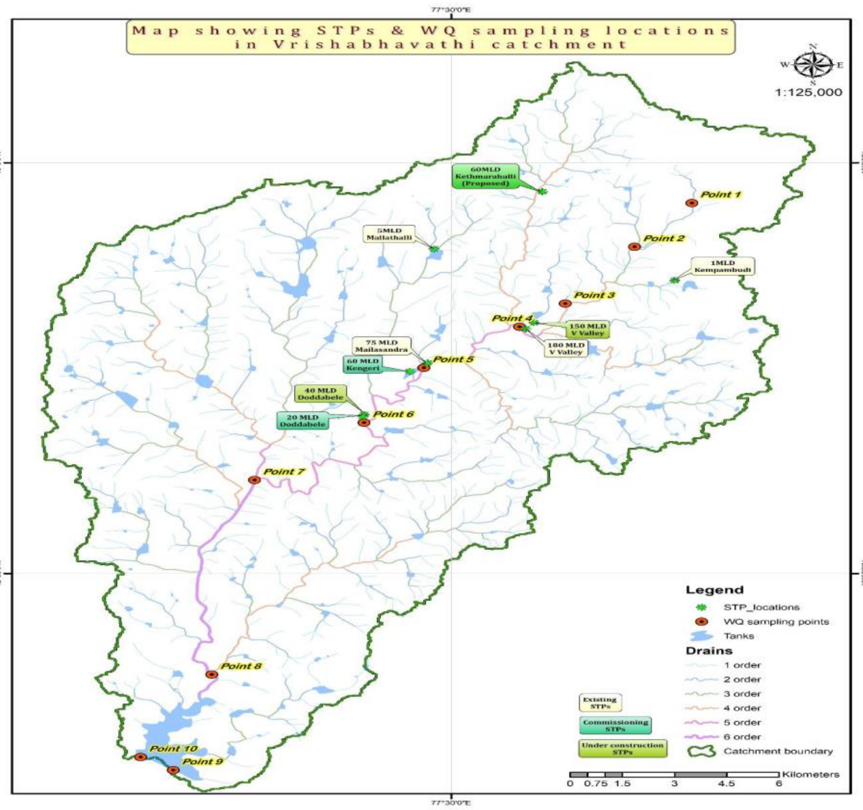


Figure *: sampling point for evaluating the in-stream Water quality

WESTERN HIMALAYAN REGIONAL CENTRE JAMMU

Scientific Manpower

S N	Name	Designation
1	Dr. S S Rawat	Scientist D
2	Dr P G Jose	Scientist D
3	Dr. R V Kale	Scientist C
4	Sh. Drona Khurana	SRA

NATIONAL INSTITUTE OF HYDROLOGY

राष्ट्रीय जल विज्ञान संस्थान

आपो हिष्ठा मयोभुवः

Work Programme for the year 2018-19

No.	Study	Team	Duration	Funding	Status
Internal Studies					
1.	Hydrological Investigation of Natural Water Springs of Baan Ganga watershed in Jammu & Kashmir State	SSRawat P Kumar SP Rai RV Kale*	02 years 11 months (May 2015 to Mar 2018)	NIH	Ongoing/ Extension requested for 06months
2.	Performance evaluation of 2D-VPMM and 2D-explicit schemes for two-dimensional overland flow simulation.	RV Kale MK Goel M. Perumal	12 months (Apr 2017 to Mar 2018)	NIH	Likely to complete by April 2018
3	Hydrologic and hydraulic modeling for floodplain inundation mapping under future climate change scenarios: A case study of Tawi River, India.	RV Kale MK Goel PG Jose SSRawat R Sharma	03 years (Apr 2018 to Mar 2021)	NIH	New proposal
4.	Estimation and Assessment of Hydrological Characteristic of a Western Himalayan river	D Khurana MK Goel PG Jose SSRawat RV Kale	12 months (Apr 2018 to Mar 2019)	NIH	New proposal
5.	Web GIS based Spring inventory for vulnerability assessment and hydro-geological investigation of selected springs for sustaining local water demand in Ravi Catchment of Himachal Pradesh"	SSRawat PG Jose SP Rai RV Kale	04 years (Apr 2017 to Mar 2021)	NHP (69.00 Lakh)	Ongoing
6.	Integrated Studies of Himalayan Cryosphere using Space Based Inputs (ISHC)	PG Jose RJ Thayyen	02 years Sept 2017 to Sept 2019	SAC/ISRO	Ongoing
Consultancy Projects					
1.	Establishment of Silt Observation Post (SOP) in the Baglihar HEP catchment	P Kumar PG Jose SS Rawat	06 months (Mar 2016 to Oct 2016)	Dept. of Soil & Water Conservation, Govt. of Jammu & Kashmir	Ongoing/ Extension upto June 2018

1. Hydrological Investigation of Natural Water Springs of Baanganga watershed in Jammu & Kashmir State

Baanganga is a small tributary of Chenab river, the legendary river associated with the miracles and legends of *Mata Vaishno Devi*. It is considered sacred and as is normal Hindu tradition, devotees like to bathe in it before preceding the journey of the holy shrine *Mata Vaishno Devi*.This river is originated from the Trikuta hills and passes from the side of Katra town. Since, there is no glacier presented in the Baanganga catchment, hence springs are the only available sources to fulfill the water demand of the livelihood of the surrounding people and also to maintain the flow of the river Baanganga. However, due to ecological degradation in Trikuta mountain range, the discharge of theses springs has significantly reduced and some of the springs have dried-up. Consequently, people of the area are facing acute shortage of water for their livelihood and there is hardly any water flowing in Baanganga. Keeping in view the above points, a study related to natural water springs of Baanganga watershed has been approved in 20th RCC meeting of WHRC held during May, 2015.

Recession curves of Bhoomika Devi Spring and Nawain Spring was analyzed and depletion time of the springs were found to be 6.96 and 6.52 months, respectively. Presently, both the springs can outlast the most extreme dry spell (5.2 months) recorded in Western Himalaya during 1951-2007, but high discharge variability about 200% in Bhumika devi spring indicates that the spring need to be regularly monitored. Bhoomika Devi spring catchment whose detailed geological mapping was carried out, is located in the proximity of Main Riasi Thrust and the spring system is located within the Riasi Thrust Zone. Lithology consists of Neoproterozoic Sirban Limestone Formation (dolostones, limestones, shales, breccia and chert) in thrusted contact with Plio-Pleistocene Siwalik Group (sandstones and conglomerates). The rocks are intensely fractured and the carbonates are extensively karstified, with gouged rocks called olistostrome. The bedding planes, cleavage and the fractures parallel the behaviour of the Riasi Thrust plane, which is curvilinear and undulatory. The fractures are oriented in every direction, and two fracture sets (steep, sub-vertical to vertical and dipping towards SE and SW) are very prominent and present throughout the study area (Fig. 2). The fractures are very mobile and dynamic, and respond to the direction and intensity of movement along the active Riasi Thrust. The intense deformation and gauging of the fractures has rendered the sealing of the older fracture sets and at the same time has opened new fractures. Hence, an overall fracture analysis of the entire region is warranted to identify the possible zones that could seal/open in the near future. Other springs in Baanganga catchment possibly has suffered the same fate, but this needs to be investigated further.

2. Web GIS based Spring inventory for vulnerability assessment and hydro-geological investigation of selected springs for sustaining local water demand in Ravi Catchment of Himachal Pradesh”

In compliance of the Objectives of the study, the following activities have been carried-out as per the proposed work plan of the PDS during 2018-19:

a. Recruitment of project staff

As per project proposal, 01 Junior Research Fellow (JRF) for year 02 to year 04 was approved for performing the Chemical analysis of springs water samples, data analysis, installation and maintenance of field instruments and report preparation. By following the standard procedure of recruitment of project staff, 01 JRF was selected through interview and joined on 29.10.2018 at WHRC, Jammu.

b. Conduct survey for identification of springs in the catchment area and collection of water samples for water quality analysis

About 300 springs have been geo-tagged and surveyed (Fig 1). More than 25 parameters have been collected during the survey along with in-situ measurement of spring discharge, and physical parameters pH, EC, clour, odor, and taste (Fig. 2&3). Furthermore, samples for detailed water quality analysis have been filled from all surveyed springs and these samples are under testing at water quality lab of WHRC, Jammu.

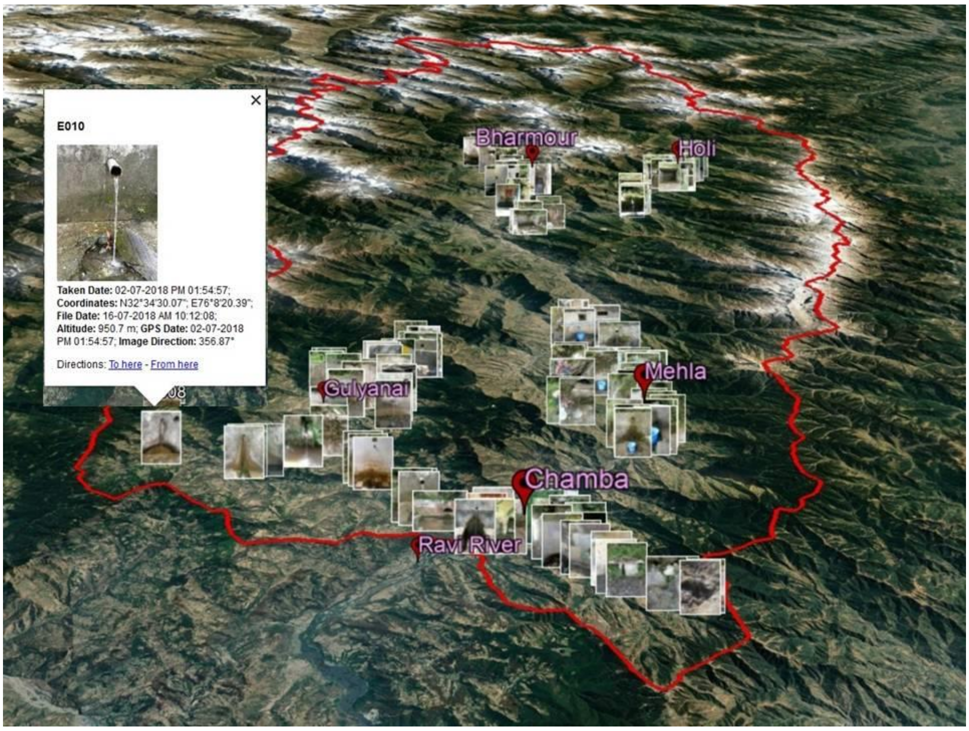


Fig. 1: Typical view of geo-tagged spring based information system of Ravi river catchment of Himachal Pradesh.

c. Creation of Web-enabled spring inventory

A spatial database inventory of data collected from field is developed using PostGIS and it is being updated with the new data as and when received. A Web based Spring information system with all the basic mapping functionalities is under development. The web information system is being developed using open source technology like Open layers, GeoExt, PostGIS, and PHP. The information system contains the study area boundary and spring locations. The information system provides the comprehensive details of springs of Ravi Catchment of Himachal Pradesh.

3. Performance evaluation of 2D-VPMM and 2D-explicit schemes for two-dimensional overland flow simulation

Estimation of overland flow is essential in addressing many hydrological and environmental problems such as flood estimation, soil erosion and non-point source pollution. Modeling of overland flow can be done using the equation of continuity and motion. The literature is replete with modelling of overland flow using one-dimensional flow description. But a one-dimensional model generally may not be able to simulate runoff generation on land surfaces characterized by irregular slopes. To overcome this problem, attention is focused in the recent times on the development of two-dimensional overland flow model. Two-dimensional overland flow modelling require the use of continuity equation describing the flow variation in x and y directions and the flow depth variation in time. Generally simplified forms of the momentum equation describing momentum variation in x and y directions are employed. For all the practical purposes these equations are solved using the numerical methods. One of the solution procedures is based on the two-dimensional explicit finite difference scheme.

To address these issues, the present study attempts to develop a computer code for two dimensional diffusion wave (DW) overland flow simulations using the explicit solution scheme (2D DW Explicit Model) is in MATLAB R2013a software. In case of V-catchment in which two overland flow plane joining the channel at middle of these two planes, the channel routing is carried out by using 1D-VPMM method. The two-dimensional Variable Parameter Muskingum McCarthy method named as 2D-VPMM method which is developed by Perumal and co-researchers (PI of this study is also main contributor in the 2D-VPMM model development) for the simulation of two-dimensional overland flow (Shakya, 2015) and computer code written in MATLAB is used to verify the results by 2D DW Explicit Model and to compare the predictive abilities of these two computational schemes. A tilted V-Catchment used by Di Giammarco et al. (1996) and the data collected from the rainfall - runoff study of laboratory catchment of the University of Illinois, Urbana Champaign, USA has been used to verify as well as to compare the results by these two methods. Based on the conducted study, it was found that the 2D-VPMM method is performing slightly better than the 2D DW Explicit Model in terms of accuracy and execution time.

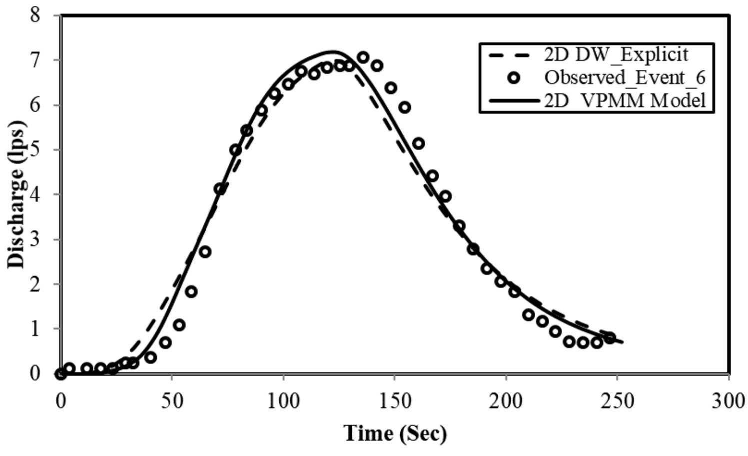


Figure – 7: Comparison of simulated/observed hydrograph for a laboratory catchment, University of Illinois, Event 6.

4. Integrated Studies of Himalayan Cryosphere using Space Based Inputs (ISHC)

a. NIH-SAC/ISRO Joint Field work to Drang Drung Glacier, Zanskar Valley, Ladakh (03-17.09.2018)

Joint Field work was conducted by NIH and SAC/ISRO researchers on Drang Drung Glacier in September 2018. Ablation stakes installed in September 2017 by the NIH team were located and geotagged for estimating annual ablation and ice surface velocity. Annual surface ablation of >2 m. was observed for all the stakes, with very little horizontal displacement. The preliminary outlook is of minimal surface velocities combined with high ablation in lower ablation zone during 2017-2018 hydrological year. However, the observations were limited by use of handheld GPS for geotagging and the limited number of observations.

A discharge site was identified through field survey by NIH researchers and was geotagged. Also geotagged were various glacio-morphological features like moulines, supraglacial channels, etc.

Photo: NIH-SAC team on Drang Drung Glacier, Zanskar Valley, Ladakh (Sept. 2018)

The 2018 fieldwork also included mapping of the glacier terminus and the proglacial lake through DGPS survey. For this a Base Station was established on exposed rock downstream of the glacier terminus. DGPS survey was carried out along the central flowline of the glacier and along a couple of transverse profiles in the lower ablation zone of the glacier. Also DGPR survey was conducted along the two transverse profiles to estimate ice thickness. The data for these are being processed at SAC, Ahmedabad.

Photo: Establishing DGPS Base Station near Drang Drung Glacier, Zanskar Valley, Ladakh (Sept. 2018)

b. Presentation of progress of project at SAC (ISRO) Ahmedabad (14.11.2017)

Participated in the meeting and presented the report of the progress of the project including the field work in DrangDrung Glacier, Zanskar Valley, Ladakh and held discussion with SAC scientists regarding future direction for the project.

c. Isotopic and hydrochemical analyses of water samples

Water samples (12 Nos.) were collected from supraglacial channels, proglacial channels and lakes for isotopic and hydrochemical analyses. These were analysed at the Hydrological Investigations Division. The results are being interpreted.

5. Assessment of Hydrological Characteristics of a Western Himalayan River

- Literature review is being done
- Morphometry has been done and a paper has been published in IJMSR journal
- Discharge data has been requested from CWC
- LULC map has been prepared for current scenario and model setup in SWAT is initiated

GANGA PLAINS SOUTH REGIONAL CENTRE BHOPAL

Scientific Manpower

S N	Name	Designation
1	Mr. Tej Ram Nayak	Scientist E
2	Mr. R V Galkate	Scientist D
3	Mr. T. Thomas	Scientist C
4	Mr. R K Jaiswal	Scientist C
5	Mrs. Shashi P.Indwar	Scientist C
6	Sh. Anoop Rai	SRA

Work Programme for the year 2018-19

S.No.	Name of the project	Team	Duration	Funding
Sponsored Projects				
1.	Modeling of Tawa Reservoir Catchment and Development of Tawa Reservoir Operation Policy under Climate Change	Shashi P.Indwar (PI) T. Thomas T.R. Nayak R.V. Galkate R.K. Jaiswal N.C. Ghosh Sumat Kumar	3 Years Started in Sept. 2017	PDS (under NHP)
2.	Evaluation of impact of Rabi irrigation in Ganga River sub-basin of Madhya Pradesh	R.V. Galkate (PI) R.K. Jaiswal T.R. Nayak T.Thomas Shashi P. Indwar	3 years Started in Nov. 2017	PDS (under NHP)
3.	Impacts of Upcoming Irrigation Projects and Climate Change on the Droughts and Desertification Scenario for Chambal Basin in Western Madhya Pradesh	T.Thomas (PI) R.V. Galkate R.K. Jaiswal Shashi P.Indwar P.C. Nayak Surjeet Singh B.Venkatesh	4 years Started in 12/2017	PDS (under NHP)
4.	Modelling of Narmada using GWAVA. (International Collaborative Project with CEH Wallingford, UK)	Sanjay Jain (PI) T.Thomas P K Mishra Manish Nema Sharad Jain	2 years Started in 04/2015	World Bank
5.	Revival of Village Ponds through Scientific Interventions in Sagar District	T.Thomas (PI) S.Goyal Vivek Bhatt Jyoti Patil	2 years Started in 09/2017	DST
6.	Development of water allocation plan of a Neeranchal watershed in Chhattisgarh	A.R. Senthil T.R. Nayak Jyoti Patil Rajesh Agrawal	2 years (04/2018—3/2010)	DoLR (under NNWP)
7.	Hydrological evaluation of existing water conservation/ harvesting structures of Jashpur and Kanker districts of Chattisgarh	T.R. Nayak (PI) R.V. Galkate T. Thomas R.K. Jaiswal	2 years (04/18-03/20)	DoLR (under NNWP)
8.	Hydrological evaluation of existing water conservation/ harvesting structures of Dewas and Jabalpur districts of Madhya Pradesh	R.V. Galkate (PI) T.R. Nayak (PI) R.K. Jaiswal T.Thomas	2 years (04/18-03/20)	DoLR (under NNWP)
9.	Hydrological evaluation of existing water conservation/ harvesting structures of Kuchch and Surendra Nagar districts of Gujarat	T.Thomas (PI) R.K. Jaiswal R.V. Galkate T.R. Nayak	2 years (04/18-03/20)	DoLR (under NNWP)
10.	Hydrological evaluation of existing water conservation/ harvesting structures of Jodhpur and Udaipur districts of Rajasthan	R.K. Jaiswal (PI) T.R. Nayak T.Thomas R.V. Galkate	2 years (04/18-03/20)	DoLR (under NNWP)

Study-1

Purpose Driven Studies under NHP

Title of the Project:

Evaluation of Impacts of Rabi Irrigation in Ganga River Sub Basinsof Madhya Pradesh (PDS Code: NIH-1_2016_1)

Study Group:

Lead Research Institution: National Institute of Hydrology

PI	R.V. Galkate, Scientist-E
Co-PI	Er. R. K. Jaiswal, Sc-D Dr. T.R. Nayak Dr. T.Thomas Ms.ShashiPoonam Indwar, Sc-C

Participating Organization:

- National Institute of Hydrology, Regional Centre, Bhopal
- Water Resources Department (WRD), Madhya Pradesh, Bhopal

Duration: 3 years

Budget: Total Cost of Project (Revised): Rs. 54.512 lakh

Introduction and objectives

The Purpose Driven Study (PDS) envisages the impact of Rabi irrigation development in Ganga sub basin part of MP on hydrology, agricultural growth, economy and public health of the region. It also envisages the performance evaluation of the selected irrigation projects using suitable indicator and development of web based dynamic application for performance evaluation of irrigation project, which will be integrated with India-WRIS or NHP Web portal so that PDS output can be utilized for the other areas also. The web based dynamic application will enable irrigation project managers of the region to evaluate performance of projects under their control with the use of project related data and information as an input. Objectives of study are as below.

Evaluation of impacts of Rabi irrigation on hydrology, agricultural growth, economy and public health for selected irrigation projects in Ganga basin.

- Performance evaluation of medium/minor irrigation projects.
- Development of web based dynamic application for performance evaluation of irrigation project.
- Recommendation of strategies to improve the performance of irrigation projects, dissemination of knowledge and findings through trainings and workshops.

Progress Achieved

Under the PDS project work activities, rainfall and groundwater data of stations near to all dam sites selected for study have been collected and rainfall analysis has been carried out. Detail data of dams and command areas, crop type, cropping area, etc of Kotwal, Rajendra Prasad dam, Samrat Ashoksagar dam, Doraha dam, Jajon dam, Mala dam, Naren dam have been ollected from WRD Divisional offices Damoh, Tikamgarh, Vidisha, Bhind, Sihore, etc. GIS layers are prepared in ArcGIS which includes base map, command area, catchment area, water spread area, village map, GW observation locations, etc.

Review of literature work of the study has been completed. The detail review of related work carried out in the MP state, in India and internationally so far has been reviewed for formulation of strategies for impact evaluation of irrigation project. To conduct base line survey for impact evaluation of irrigation project, survey format including questionnaire to obtain information on hydrology, agriculture, socio-economy and health aspects in command area has been prepared in Hindi. The survey will be conducted by classifying marginal and big farmers according to their land holding size in head, middle and tail reach area of command. The farmers within those groups will then be selected randomly.

Study-2

Title of the Project:

Impacts of Upcoming Irrigation Projects and Climate Change on the Droughts and Desertification Scenario for Chambal Basin in Western Madhya Pradesh

Study Group:

Lead Research Institution: National Institute of Hydrology

PI	Dr. T. Thomas, Scientist-D	
Co-PI	Dr. P.C. Nayak, Sc-D Dr. Surjeet Singh, Sc-E Dr. B. Venkatesh, Sc-F	Er. R.V. Galkate, Sc-E Er. R. K. Jaiswal, Sc-D Ms.ShashiPoonam Indwar, Sc-C

Partner Institution: Water Resources Department (WRD), Madhya Pradesh

PI	Director, Hydrometeorology, WRD, Bhopal.	
Co-PI	Sh. M.K.Paliwal, Dy.Director, WRD, Bhopal Er.SanjivDas,Dy.Dir.& DBA, WRD, Bhopal	Mr. Sunil Vyas,Dy. Director Mr.Girish Sharma, SDO

Study area:

Chambal basin in Madhya Pradesh comprising of its right bank tributaries including Parvati river, Kalisindh river, Newaj river and Chambal river covering the districts of Mandsaur, Ratlam, Rajgarh, Guna etc. in Madhya Pradesh

Objectives:

- Assessment of climate change signals in Chambal basin.
- Evaluation of drought characteristics and investigation of the desertification.
- Hydrologic modelling for simulation of the hydrological processes in the basin.
- Assessment the impact of climate change under alternate climate scenarios on the future water availability, drought and desertification.
- Evaluation of the impacts of upcoming irrigation projects on the drought and desertification.
- Integrated assessment of vulnerability to drought, desertification and climate change.

Progress/Results Achieved during 2018-19

The field visits to some of the districts were accomplished and the relevant data on hydrometeorology and project related information was collected from the concerned departments. Visits were made to the Kundaliya and Mohanpura dams located in Rajgarh districts as well as the Gansghisagar Dam in Madhya Pradesh and Rana Pratap Sagar Dam and Kota barrage in Rajasthan. The literature review pertaining to the various aspects in the project have been completed. The formalities regarding the collection of the classified hydrological data from CWC Yamuna basin is completed and it shall be collected shortly. The various thematic layers pertaining to the land use / land cover, soils texture, hydro-geology, topography etc., has been completed. The assessment of the climate change signals based on the historical datasets has been completed. Similarly the changes in the decadal changes in the land use have been determined. A Stakeholders Workshop has been conducted and the progress of the studies was showcased. The annual progress of the study was presented before the NHP Review Committee. The Status Report was completed and submitted to the PDS Coordinator for review.

Study-3

(Special PDS under Centre for Excellence in Hydrologic Modelling)

Title of the Project:

Integrated Assessment of the Impacts of Climate Change and Land use Change on the Hydrology of the Narmada basin through Hydrological Modelling Approaches

Project team:

Lead Research Institution: National Institute of Hydrology

PI	Dr. T. Thomas, Scientist-D	
Co-PI	Dr. Surjeet Singh, Scientist-E Dr. B. Venkatesh, Scientist-F Dr. P. C. Nayak, Scientist-D Dr. ArchanaSarkar, Scientist-D Er. Manish Nema, Scientist-C Dr. Prabhash Mishra, Scientist-C Er. Shashi P. Indwar, Scientist-C	Dr. Sharad Jain, Scientist-G Dr. N.C. Ghosh, Scientist-G Dr. J. V. Tyagi, Scientist-G Dr. Sanjay K. Jain, Scientist-G Dr. M. K. Goel, Scientist-G

Partner Institution: Water Resources Department (WRD), Madhya Pradesh.
M. P. Council of Science & Technology, Bhopal.

PI	Director, Hydrometeorology, WRD, Bhopal.
	Dr.SandeepGoyal,Sr. Principal Scientist, MPCST
Co-PI	Sh.Sanjiv Das,Dy. Director & DBA, WRD,MP Sh. M. K.Paliwal, Dy.Director, WRD,MP

Objectives:

- Application of hydrological models for simulating the present and future water availability under climate and land use change scenarios.
- Assessment of future water availability under alternate scenarios of climate change and land use change for the near-term (2006-40), mid-term (2041-70) and end term (2071-99).
- Water allocation planning and optimal water use based on future water availability scenario.
- Assessment of Environmental Flow Requirements (EFR) for various river reaches in the study area.
- Characterization of extreme events including droughts and floods.

Progress/Results Achieved during 2018-19

The project proposal was presented at NIH Roorkee in June 2018 in the meeting for the model development activities being undertaken under the Centre for Excellence in Hydrologic Modeling. The hydrological data pertaining to the Narmada river and its tributaries have been collected from CWC, NBO, Bhopal. Information pertaining to the projects have been collected from NCA, Indore. Also filed visits were made to the Bargi dam and its command area for collection of data pertaining to the reservoir operation. The collection of the hydro-meteorological data from IMD is in progress. The rainfall data for Narmada basin has been collected from WRD, Bhopal. Similarly the groundwater level data and related information has been collected from CGWB Bhopal and Groundwater Survey, WRD, Bhopal. The study area has been delineated and the data collection is in progress. A comprehensive soil sampling exercise was carried out for Narmada basin upto Hoshangabad alongwith the infiltration and saturated and unsaturated hydraulic conductivity. The analysis of the soil samples is being carried out at the Soil Lab at NIH Roorkee. The land use / land cover classification has been completed and the soil maps prepared. The assessment of climate change signals for the historical time period has been completed.

Study-4

Title of Project:

Modelling of Tawa Reservoir Catchment and Development of Tawa Reservoir Operation Policy

Name of PI : Er. Shashi Poonam Indwar

Budget : 25.46 Lakh World Bank funding

Duration : 3 Years (September 2017-August 2020)

Study Group:

Lead Research Institution: National Institute of Hydrology

PI	Ms.ShashiPoonam Indwar, Sc-C
Co-PI	Dr. T.Thomas, Sc-D Dr. T.R. Nayak, Sc-F R.V. Galkate, Sc.-E Er. R. K. Jaiswal, Sc-D

Objectives of the study are as follows:

- Assessment of the present supply-demand scenario for Tawa reservoir.
- Establishment of a comprehensive hydrological model for Tawa river basin up to Tawa reservoir.
- Evaluation of future supply-demand scenario.
- Reservoir operation for optimal utilisation of future water resources.

Work Plan and Activity Progress for the period (March, 2018 to Feb., 2019)– 1rst Year

Modeling of Tawa Reservoir Catchment and Development of Tawa Reservoir Operation Policy

The Tawa River is one of the important left bank tributary of Narmada River and the Tawa dam a major irrigation project, is located on it. The management of any reservoir system from planning to operation is quite challenging as it deals with diverse complex variables and uncertainties viz., inflows, return flows, storages, diversions, inter/intra-basin water transfers, irrigation demands, hydropower demands, industrial demands and municipal water supply demands (Rani & Moreira, 2010). The reservoir management strategies should be based on the hydrological response of the catchment as well as the water utilization pattern in the command areas. Both the left bank canal (LBC) and right bank canal (RBC) of the Tawa dam caters to large command area, which is largely located outside the extent of the confluence of Tawa River with the Narmada River. The Tawa river basin is however considered to be a water sufficient basin but in future water allocation to the competing water users will be quite challenging as increase in demand. Looking into the population growth related impacts and uncertainties in future, the management of the available water resources including the management and operation of the Tawa reservoir should be challenging as well as an interesting case study for devising targeted adaptation plans for the various stakeholders. In such an uncertain futuristic scenario, the assessment of the impacts of population growth on the water availability in the reservoir and the subsequent impacts on meeting the committed demands for the domestic, industrial and agricultural sector is necessary. The study shall cater to these issues and will explore the possibilities of formulating revised reservoir operation policies to address the altered future supply-demand scenario in the basin. Activities done are listed below

- Cropping pattern followed in the command area in Kharif and Rabi season
- Landuse/Land cover classification in the catchment and command area using digital data

- Assessment of present supply-demand scenario using detailed water balance techniques-under this each component of water balance has been computed using cropwat tool, mathematical equations and techniques.
- Irrigation water Demand and Supply in Tawa Command areaof Tawa Reservoir in Hoshangabad District-Crop Water Requiremant and Irrigation Scheduling of Kharif and Rabi Crops using CROPWAT 8.0 in Tawa Command Area.

Study-5

Title of the Project:

Modelling of Narmada using GWAVA.

Study Group:

PI	**Dr. T. Thomas, Sc-D, NIH-RC Bhopal.**	
Co-PI	From NIH Roorkee Dr. Sharad Jain, Director Dr. Sanjay Jain,Sc G Dr. P K Mishra, Sc-C Er. Manish Nema, Sc-C	From CEH Wallingford, UK Dr. Gwyn Rees, Science Head WR, Ms. Helen Houghton-Carr, Senior Hydrologist Mr. Nathan Rickards, Hydrologic Modeller

Project Partners: Centre for Ecology & Hydrology, Wallingford, UK.

Study area: Narmada river basin up to Hoshangabad in Madhya Pradesh.

Objectives:

- Collection and processing of historical data
- Modeling of rainfall runoff.
- Future climate change and land use change projections.
- Impact of changes on the water availability.

Progress/Results Achieved during 2018-19

The GWAVA hydrological model setup for the Narmada basin up to Hoshangabad has been extended to cover the complete Narmada basin based on the decisions taken during the Brainstorming Session on “Capabilities of Hydrological Modeling in Decision Making” was organized jointly by NIH and CEH at PICU, WRD Bhopal on 9th March 2018. GWAVA is a gridded model and the model was setup for the complete basin at a resolution of 0.125o x 0.125o. All mandatory input data including DEM, land use/land cover, soil type, population density map, livestock density map, season-wise cropping pattern etc. have been prepared in GIS environment and data input extracted in ASCII format. All the major dams in the basin including Bargi dam, Tawa dam, Barna Dam, Indira Sagar Project (ISP), OSP, and Sardar Sarovar Project (SSP) have been incorporated in the model alongwith their command areas and water use. The water transfers from Narmada basin to Bhopal, Indore, as well as transfers out of the basin to Shipra basin was incorporated in the model. The future water transfer to Ganga basin through the right bank canal from Bargi dam has been incorporated in future developmental scenarios. The model has been use to study the impact of climate change, land use change and planned developmental activities on the hydrology of the basin including the water availability in the future. The calibration and the validation runs have been completed and the model has been driven using the future climate data to assess the future streamflow and water availability in the basin. The report writing as well as the manuscript preparation is in progress.

Study-6

(Sponsored project under R&D programme of DST)

Title of Project:

Revival of Village Ponds through Scientific Interventions in Sagar District (Sponsored R&D Project by Department of Science & Technology, Govt. of India).

Study Group:

PI	**Dr. T. Thomas, Sc D, NIH Bhopal.**
Co-PI	Dr. SandeepGoyal, Sr. Principal Scientist, MPCST, Bhopal. Dr. Vivek Bhatt, Associate Professor & Head WRM&E, WALMI, Bhopal. Dr. JyotiPatil, Sc C, NIH, Delhi Office, New Delhi.

Study area: Two village ponds in Banda block of Sagar District in Bundelkhand region of Central India.

Objectives:

- Creation of an inventory of ponds and preparation of present status of selected ponds.
- Assessment and documentation of construction, management and use of village ponds.
- Analysis for identifying the causes for the dysfunction of the selected ponds.
- Identification of possible scientific interventions and involvement of community participation for revival of the selected ponds.
- Capacity building initiatives for knowledge dissemination to the stakeholders.

Progress/Results Achieved during 2017-18

The project awarded under the R&D programme of Department of Science and Technology, Govt. of India with an aim to harvest the rainwater through surface storage in existing but dysfunctional village ponds and tanks. Two village ponds in Sahawan village and Cheelpahadi village in the Bundelkhand region in Central India (Agro-ecological zone 10) has been selected for the study as the region is under regular droughts and faces severe water scarcity during in summers. The local population, particularly women have to travel far to fetch drinking water. Moreover the agricultural productivity is very low due to non-availability of assured water for irrigation. The progress of the study was presented at the DST Progress Review Meeting held at Punjab Agricultural University (PAU), Ludhiana which was reviewed by Dr. Bhoop Singh, DST and Prof. S. Kukkal, Programme Coordinator. Many field visits were carried out to the Bundelkhand region by the team of Scientists from NIH, WALMI and MPCST. The catchment area and the water spread area of these village ponds have been delineated using SRTM digital elevation model as well as the survey of the catchment and water spread area of the ponds was carried out by Total Station Survey. The area-elevation-capacity table has been prepared for these ponds. Interactions held with the local administration to channelize their departmental funds for the activities were very helpful and many activities could be performed through convergence. The contour trenching work in the degraded slopes were carried out by the district administration. The fencing of the pond (partly) was carried out from the funds of the local MLA of Banda block. The desilting of the Sahawan village pond was done through RES. The water quality sampling is being carried out at regular intervals and analysis is being carried out at NIH Bhopal. The infiltration and hydraulic conductivity tests were performed. The soil analysis has also been completed. The First Interim Report was submitted for DST for review. The study is progressing well. A Consultation Workshop with the villagers was held at Sahawan village and a livelihood expert suggested alternate livelihood options for them. The next Progress Review Meeting is planned at NIH Roorkee in June 2019.

COMPLETED STUDIES DURING 2018-19.

Study-1

1. Title of the project:

Groundwater Flow Modeling in Lower Bina river basin

2. Project Team:

PI	Er. Shashi Poonam Indwar, Scientist-C	
Co-PI	Dr. T.R. Nayak, Scientist-E Dr. T. Thomas, Scientist-D Sh. R.V. Galkate, Scientist-E	Sh. R.K. Jaiswal, Scientist-D Dr. N.C. Ghosh, Scientist-G

The objectives of the study is (i) to analyze and model the groundwater flow paths in Lower Bina river basin (ii) to determine in detail the groundwater movement and assess the interaction between the groundwater aquifer and the lower Bina River using Visual Modflow Flex /Visual Modflow Software/Tool. Data collection and base data computerization: The baseline data such as groundwater level measurements, river stage at different locations of the Bina River for flow modeling have been collected from CGWB and CWC respectively. Daily meteorological data for 16 years from 2000 to 2016 have been collected, graphs have been plotted to show the trends of groundwater levels using Mann kendall and Sen's Slope estimator. The Mann-Kendall test indicated falling trends at most wells and rising trends at some wells and at few wells there were no significant trends. Mann-Kendall test showed falling trend is observed in most wells during pre-monsoon and post-monsoon in both blocks signifying overexploitation of groundwater whereas no trend is observed in few wells. Sen's Slope test is used to identify the significance of the slope and it is seen that declining trend was observed at 95% confidence interval. An average temporal variation of groundwater shows declining trend in Bina and Khurai blocks. Bore log data for 4 locations, topographic information through SRTM data and generation of DEM is completed. Geological map, groundwater potential map, soil map, land use and land cover map have been generated using Geological Survey of India maps in GIS platform. Drainage map has been generated using DEM and Watershed delineation technique of ARC Hydro tool. Analysis of field data (Conceptualization of the problem, model setup, model data preparation): The Conceptualization of the flow model has been completed.DEM (Digital Elevation Model) for the study area using SRTM data has been generated. Aquifer characterization is completed using Rockworks. Various hydrogeological and hydraulic data for setting up the flow model is completed. Groundwater flow model calibration is done for the year 2016 for pre-monsoon and monsoon and validation is completed with respect to 2017 pre-monsoon (May). A finite difference model generated for groundwater flow analysis of lower Bina river watershed in Bina block. The conceptual model calibrated for steady state condition and validated for steady state conditon through USGS 3D Finite Difference code, Visual Modflow .Various applications tried out on the calibrated model such as recharge to the aquifer, reasons for drying out of wells and water logging, river-drain influencing the aquifer and well design strategies. This study outcome would be helpful for groundwater development activity in lower Bina river watershed in Bina block.

Study-2

Title of the project:

Water Balance Estimation of the Watershed IWMP-16 in Kanker District (Chhattisgarh)

Project Team:

PI	Dr. T.R. Nayak, Scientist-F	
Co-PI	Er. S.P. Indwar, Scientist-C Sh. R.V. Galkate, Scientist-E	Sh. R.K. Jaiswal, Scientist-D Dr. T. Thomas, Scientist-D

Objectives:

The objectives of the study have been framed as:

1. To develop the Water Evaluation and Planning (WEAP) applications for the watershed management in IWMP-16 in Kanker district, Chhattisgarh for the Reference year 2009-10.
2. Formulation and evaluation of the Supply and Demands under the development scenarios for the year 2010-11 to 2050-51.

Results:

The WEAP Schematic was prepared based on the watershed boundary and major drainage system and linked with the Global Coordinate System with datum WGS-84 so that the working area (IWMP-16) was linked with Global Climate Model. WEAP provides access to a "built-in" global historical gridded climate dataset, including data for temperature, precipitation and wind speed, at daily and monthly time steps for 1948-2010, at a spatial resolution of 0.25 degrees (roughly 28 km). This global climate dataset was created by the Terrestrial Hydrology Group at Princeton University. It blends reanalysis data with observations. The year 2009-10 has been considered as the base year on the 'Reference accounts year (2011)', for which the demographic data was available. The WEAP model has been run for future years 2009-10 to 2050-51 with different scenarios and assumptions. As per the suggested methodology, the required input data was fed into data view of the model, viz. precipitation, temperature, landuse, and soil parameters. The values for annual water use rate, population, and supply capacity of the sources were input; and WEAP thus gave the results for Total Water Demand, Available Supply and Unmet Water Demands of the watershed. Water Demand here is the total amount of water that is required in the region for use of various domestic and agricultural purposes. Unmet Demands are the unsatisfied water demands that require great concern and alternatives to cope up with them. The database available on human population, live stocks, agricultural area, irrigation supply from surface water and groundwater, etc. for the study pertains to the the base year or 'Reference accounts year', i.e. 2009-10. The supply sources, domestic and catchment demands, unmet water demands for the year 2010 -2050 has been analysed to compare the future years with different under different scenarios with interventions, such as population growth, decrease or increase in rainfall/runoff, etc. have been analysed through WEAP model and the results are presented in tabular as well as graphical form.

DELTAIC REGIONAL CENTRE KAKINADA

Scientific Manpower

S N	Name	Designation
1	Dr. YRS Rao	Scientist F & Head
2	Mr. S V Vijayakumar	Scientist F
3	Dr. V S Jayakanthan	Scientist E
4	Dr. P C Nayak	Scientist D
5	Mr. R. Venkata Ramana	Scientist D
6	Mr.T.Vijay	Scientist B
7	Sh. U V N Rao	PRA
8	Sh. P R S Rao	RA

The following studies are ongoing during the year 2018-19 as approved by TAC/RCC of Centre.

S.No.	Title of the Project	Team	Duration	Funding	Status
1	Groundwater Salinity Source identification in Godavari Delta, A.P	Y R SatyajiRao (PI) J V Tyagi S V Vijaya Kumar T Vijay R VenkataRamana	2017-2020 Dec., 2017-March 2020	NHP-PDS Approved by NHP PDS Rs 61.09 lakhs (SP-28/2017-18/PDS-13)	On going
2	Sedimentation Study of Hirakud Reservoir, Odisha using Optic and Microwave Remote Sensing Technology	V.S. Jeyakanthan(PI) J.V. Tyagi Y.R. SatyajiRao S.V. Vijaya Kumar R. VenkataRamana P.C. Nayak	July 2017-March 2020	Approved by NHP PDS Rs.51.19lakhs (SP-28/2017-18/PDS-3)	On going
3	Study of the behaviour of Multi-Aquifer system & Aquifer mapping for an effective Groundwater Management in Gunderu Sub-basin, West Godavari District, A.P	S V Vijaya Kumar (PI) Anupama Sharma Y R SatyajiRao T Vijay	April 2018-March 2021	PDS approved under NHP (partnership with AP SGW &WA Dept.	On going
4	Forecasting of Flash flood and management for east flowing rivers of India's Subzone 4(a).	R VenkataRamana Y R SatyajiRao	Dec 2017-Nov.2020	Internal Study	On going
II SPONSORED PROJECTS					
1	River bank Filtration (RBF) studies in coastal alluvium of Andhra Pradesh	Y R SatyajiRao T Vijay	April 2016 - March 2019	Peya Jal Suraksha Project	On going
2	High Performance Advanced Septic System (HPAS) along the villages and Roadside Restaurants	Y R SatyajiRao T Vijay	April 2018-March 2020	IC-IMPACTS (Indo Canada Project)	On going

Study 1: Groundwater salinity source identification in Godavari delta, Andhra Pradesh

Project Investigator	: Y R SatyajiRao,
Budget and Funding	: PDS- NHP (61.09 Lakhs)
Period	: Three Years (Dec 2017 to March 2020)
Status	: Ongoing

Objectives:

- Identification of groundwater salinity zones within the Godavari Delta
- Salinity Source identification using integrated approach
- Remedial measures to control groundwater salinization in Godavari delta

Progress of the study:

The Godavari Delta has been covered by East Godavari and West Godavari District in Andhra Pradesh. Most of the thematic layers are available in the form of Administrative boundaries (Districts) and all statistical data is available on Mandalwise administrative boundaries. The relevant SOI topographical sheets on 1: 50000 scale has been obtained (23 Nos) and base map has been prepared in GIS frame work. The soil map and its details are collected for the study area. Groundwater levels and water quality network has been integrated from State Groundwater Department and CGWB for identifying gaps for further monitoring of ground water quality. Godavari delta, its river mouth and important locations are shown in Figure 1. The present water quality analysis indicates that groundwater in coastal areas is susceptible to salinization by natural developments and anthropogenic factors. In addition to this, many harmful pollutants, such as agricultural fertilizer, pesticides, waste deposits, industrial effluents and aquaculture altering the chemical composition of groundwater. The shallow water quality data indicated that there is significant increase of TDS from the year 2005 to 2016 and decease in the paddy grown area from 2007 to 2016.

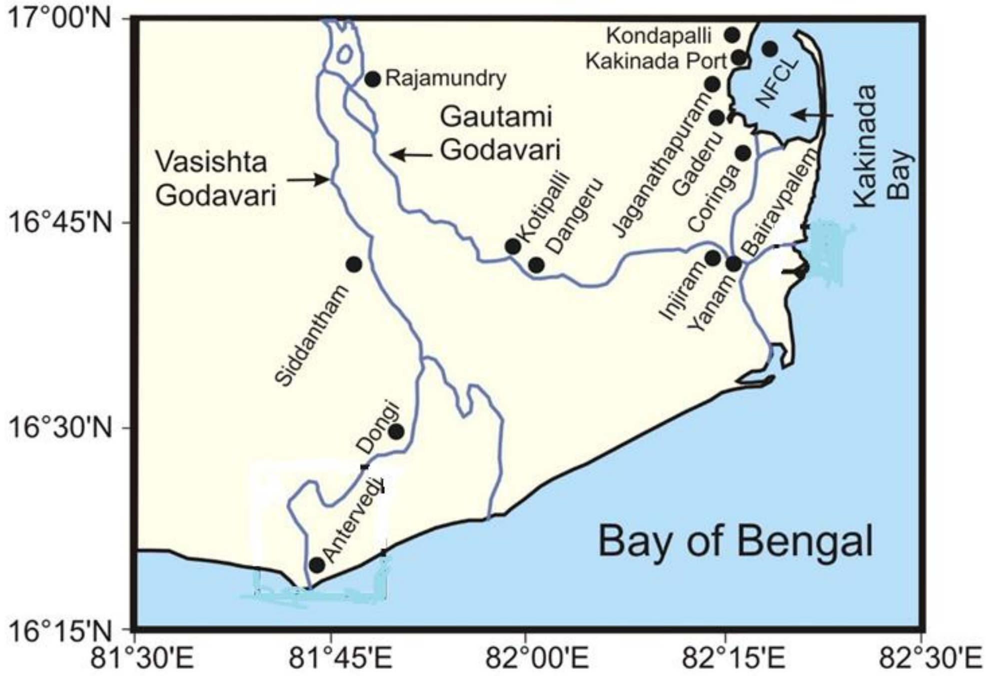


Figure 1. Location of Godavari delta and its river mouths

The areal extent of Aquaculture, which is a major threat for the salinity in the East Godavari District was collected from the AP State Fisheries Dept. Water Quality data of OB wells, Piezometers and APERP wells of East Godavari and West Godavari were collected from AP State Groundwater Dept. Spatial distribution maps of Electrical Conductivity contour maps were prepared for the entire study area for pre monsoon and post monsoon periods for the year 2017. The spatial distribution of Electrical conductivity in the study area for pre monsoon and postmonsoon of 2017 for the observation wells were presented in Fig 2 and Fig 3.

First Inception Workshop was organized on 25th July 2018 at DRC, Kakinada with the participation of local Groundwater department, Fisheries Dept, Rural Water Supply Dept.etc.

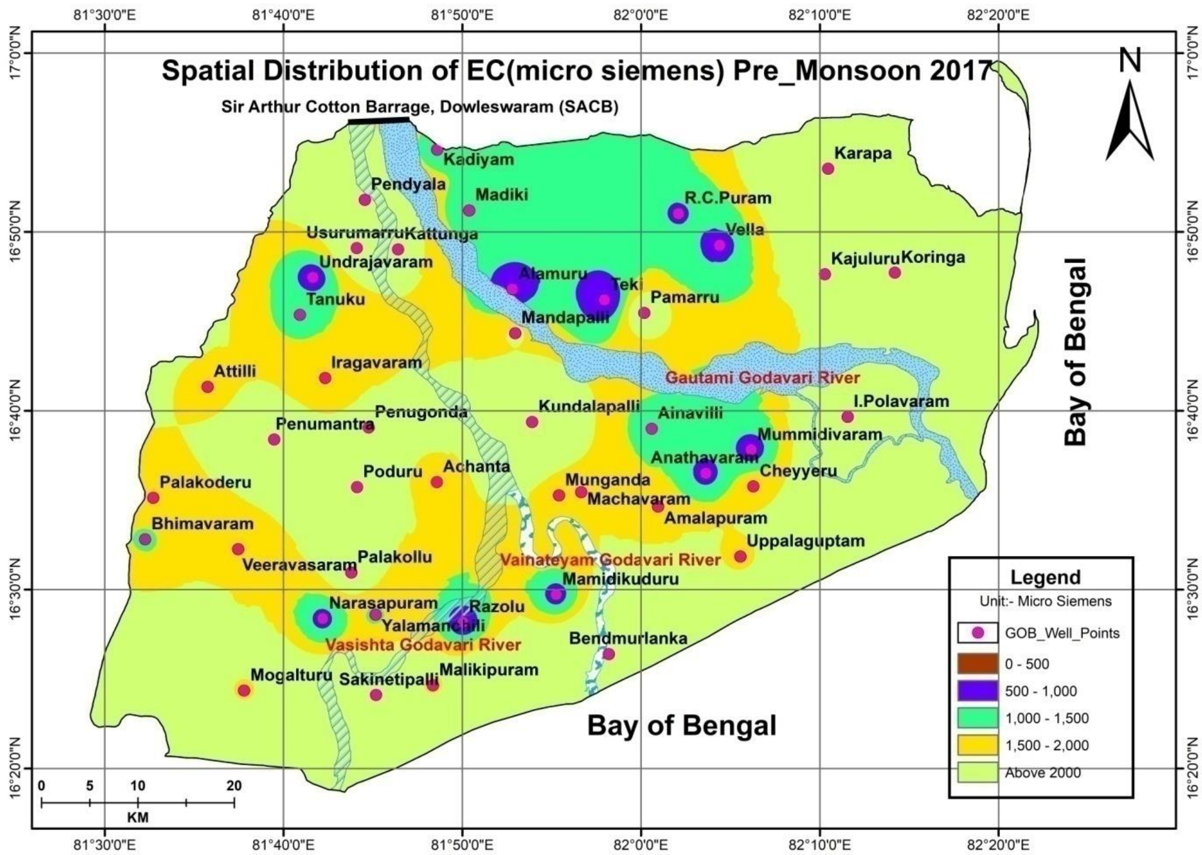


Fig.2 : Spatial Distribution of Electrical Conductivity in OB wells during Pre monsoon 2017

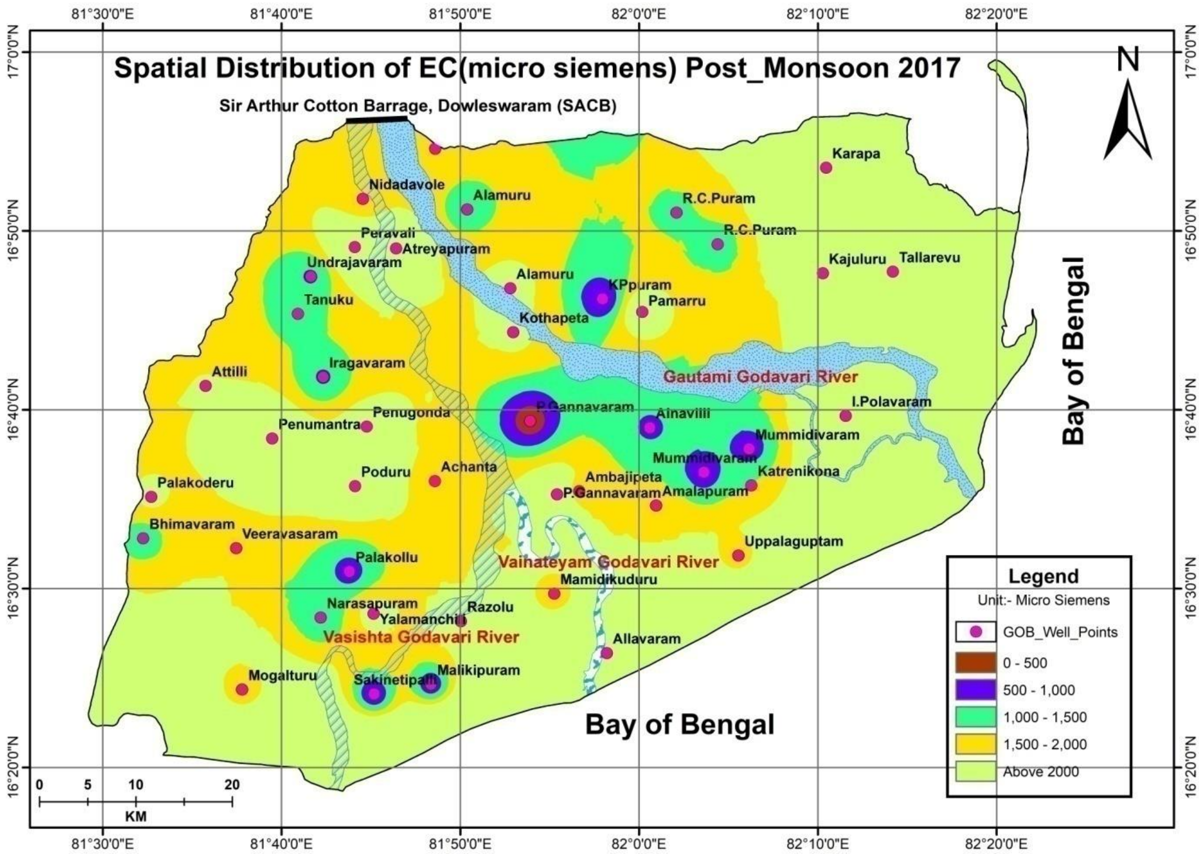


Fig.3 : Spatial Distribution of Electrical Conductivity in OB wells during Post monsoon 2017

Study 2: Sedimentation study of Hirakud Reservoir, Odisha using Optic and Microwave Remote Sensing Technology

Principal Investigator :V.S.Jeyakanthan, Scientist-E

Budget and Funding :Rs.51.19 Lakhs, NHP-PDS

Period : Three Years (2017-20)

Status :In progress

Objectives:

- To assess the best approach between
  - i. Per-pixel
  - ii. Sub-pixel and
  - iii. Super resolution classifier for the reservoir sedimentation estimation of Hirakud reservoir
- To evaluate the feasibility of using
  - i. Microwave satellite data for reservoir water-spread area estimation.
- To estimate sediment yield and prepare watershed wise soil erosion maps of the Hirakud basin using soil erosion modelling approach.

Progress of the study:

Soil map (Fig. 1) of the Hirakud catchment area was prepared using the maps obtained from NBSS&LUP, Nagar. The study area contains 26 different soil types. The soil map will be used as an input for SWAT analysis. Different soil types in the study area its drainage characteristics and area occupied by them in the catchment area has been estimated.

Landuse-landcover map of the study area was prepared using LANDSAT-8/OLI satellite data. Hirakud catchment area is dominated by agricultural land which contains different types of cash crops, paddy, sugarcane etc. The study area also contains shrubs, fallow land, forest, mining, settlement and water body. Landuse-landcover (Fig. 2) map is an input for the SWAT analysis.

Water spread area estimated form the satellite data is an input for the calculation of capacity of reservoir and in turn the sediment deposited in the reservoir. In this regard ten different water levels of LANDSAT-8 satellite data pertaining to Hirakud reservoir were analyzed and their water spread areas were estimated using per-pixel and sub-pixel classification approaches. The extracted water spread area of [illegible] on a[illegible]

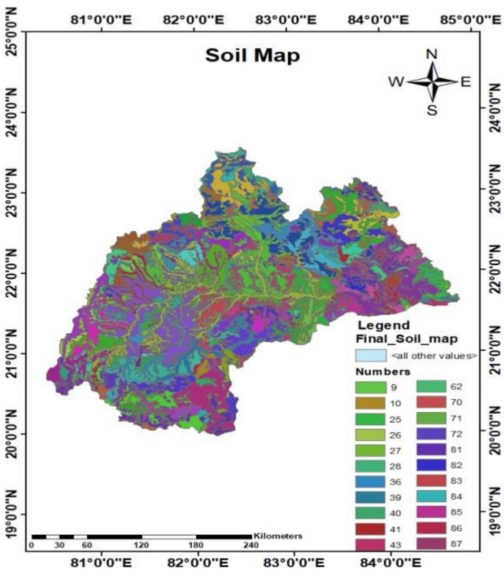


Fig. 1 Soil Map of Hirakud

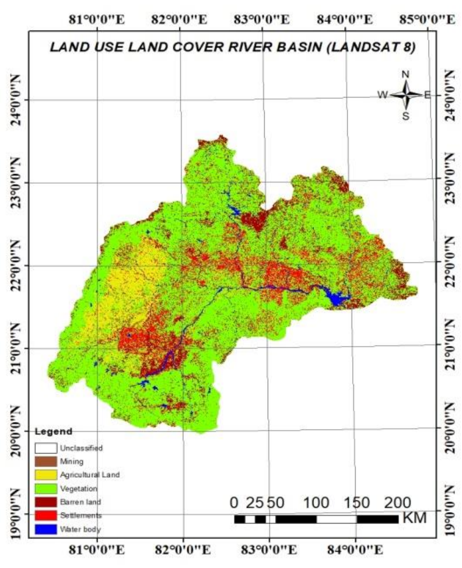


Fig. 2 LU-LC Map of Hirakud

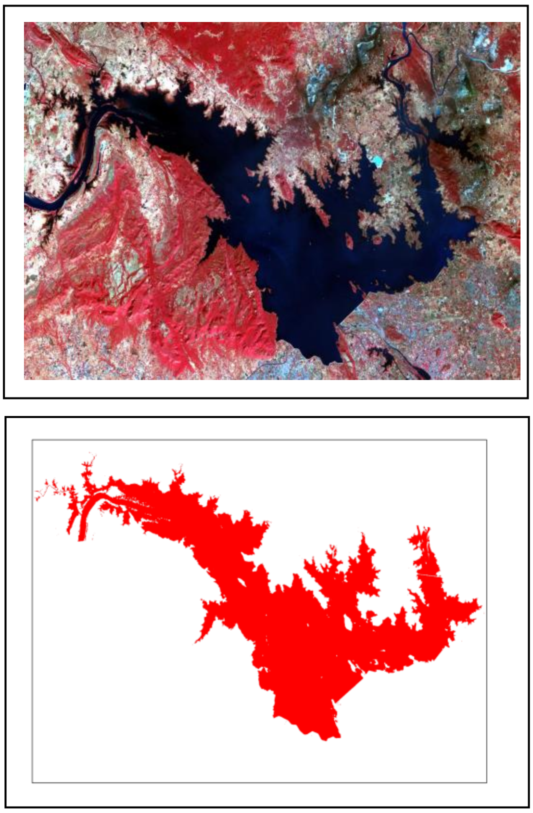


Fig 3. (i) DATE OF PASS - 16JAN18

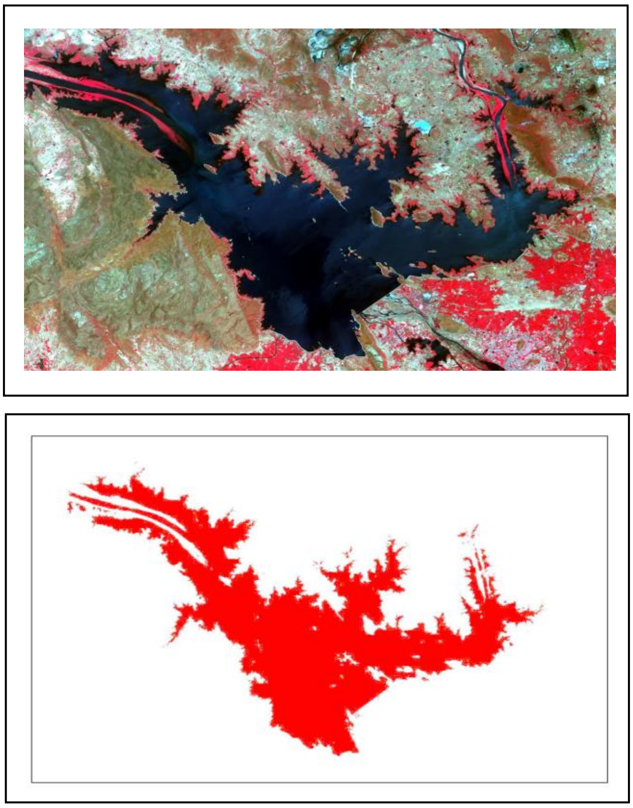


Fig 3. (ii) DATE OF PASS -

Study 3: Study of the behaviour of Multi-Aquifer system & Aquifer mapping for an effective Groundwater Management in Gunderu Sub-basin, West Godavari District, A.P

Principal Investigator: S. V. Vijayakumar

Budget and Funding :Rs.20.00 Lakhs, NHP-PDS (As Partner Agency in AP-1_2017_80 study)

Period : Three Years (2018-21)

Status :In progress

Objectives:

i. To prepare a status report on the water resources and development in the mutli aquifer system in the basin
ii. To develop conceptual hydro-geological model setup of aquifer system to establish boundary conditions of the multi aquifer system
iii. To establish aquifer characteristics and prepare data base for groundwater flow model
iv. To study of Ground water flow and suitable artificial recharge intervention as a management practice in multi-aquifer system.
v. Development of suitable Ground water flow model of Gunderu Sub-Basin from conceptual 3D multi aquifer system established.

Progress:

In view of the increasing groundwater dependency, declining groundwater levels and stress on aquifers, suitable ground water management strategies are to be evolved for sustainable development of the Gunderu Sub-basin. In any aquifer system, the natural consequence of recharge results in addition of groundwater storage. Similarly, the natural consequence of groundwater withdrawal is the removal of water from subsurface storage. Knowledge of geologic structure is very important to understand aquifer characteristics and its groundwater flow and its water level fluctuation. The scenario is complex in multi aquifer systems. Groundwater flow is mainly controlled by the continuity and interconnectedness of the aquifers, particularly in the vertical direction, rather than the hydraulic conductivity.

The samples for river water, canal water and groundwater collected during field visit in October 2018 were analysed for stable isotopes of Oxygen $^{18}O_{16}$ and Deuterium D are plotted along with meteoric water line of local precipitation and other samples of previous surveys to identify the proper source of them. The plot is shown in Fig. 1 and appears that the samples are originating from same recharge source.

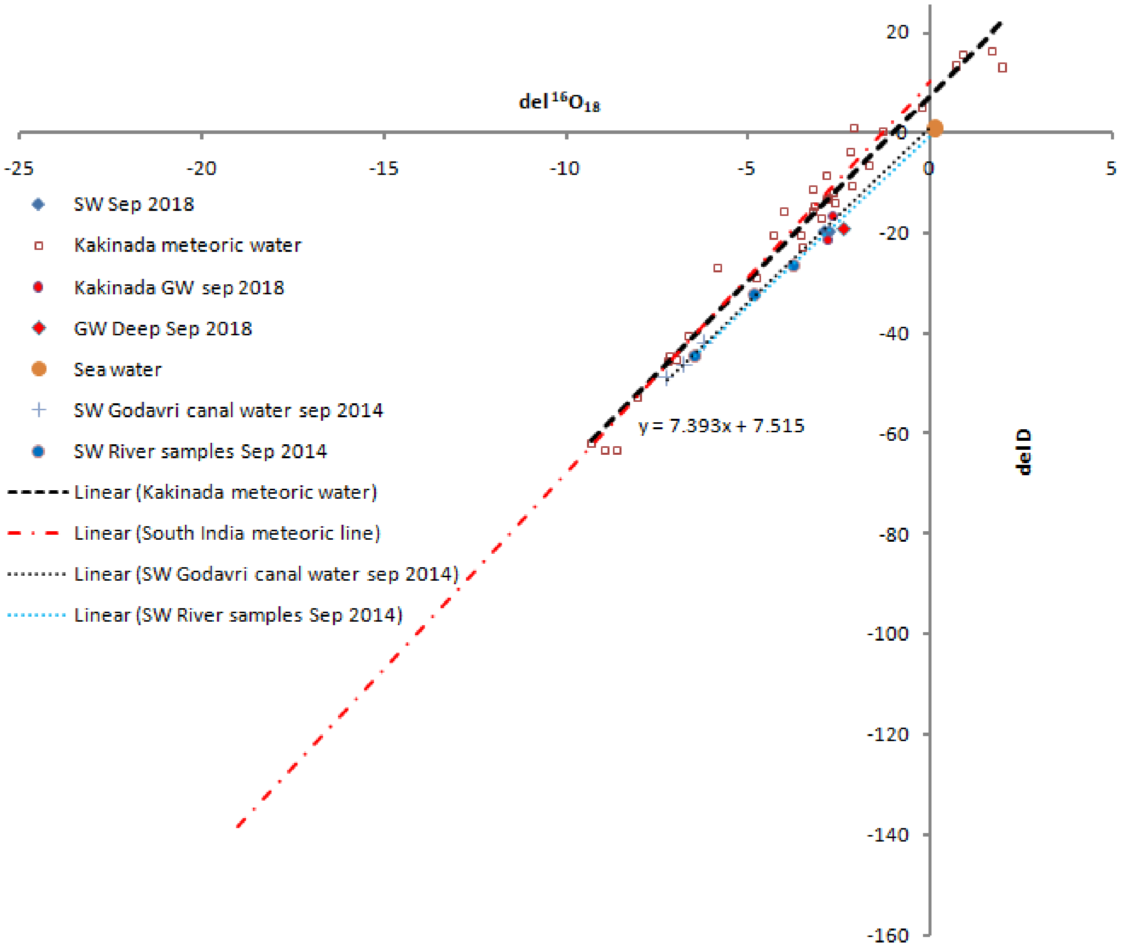


Fig.1 Plot of stable isotopes O18 and Deuterium in samples of October 2018 along with meteoric water line of local precipitation and other samples.

The investigations and analysis are continuing.

Study 4: Forecasting of Flash flood and management for east flowing rivers of India's Subzone 4(a).

Project Investigator: R Venkata Ramana.
Budget and Funding : Internal
Period : Three Years (Dec. 2017- Nov. 2020)
Status : Ongoing

Objectives:

- Study of flash flood for east flowing rivers of sub zone 4 (a)
- Analyze historical precipitation data and precipitation forecast estimates from IMD as input to such flash flood forecasting.
- Assessment of flood pattern in the region of sub zone 4(a) due to climate change.

Progress of the study:

In the proposed study hydrological model HEC HMS (the Hydraulic Engineering Center Hydrological Model System) with hydrodynamic model HEC-RAS (the Hydraulic Engineering Center River Analysis System) model would be integrated by employing IMD forecast rainfall as input. As per CWC report three basins are located in flood prone areas in the sub zone 4 (a) of the Andhra region namely Vamsadhara, Nagavali and Sarada river basins. Accordingly ASTER 30 m resolution digital elevation model (DEM) downloaded from Earth Explorer (USGS WEB site) and delineation of basin, sub-catchments and drainage network using terrain processing in HECGeo HMS model. Basin, sub-catchments and stream characteristics were determined in basin processing. Land use and land cover (LU/LC) were prepared with January 2018 Landsat 8 image downloaded from USGS web site. Discharge data collected from India-WRIS and WRD AP and rainfall collected from IMD (0.5 degree gridded) and WRD, AP of three basins. Analyse the design storm for various return periods using simple Gumble distribution. Estimated all the input parameters of the HEC HMS model and simulated the runoff for peak flood years. The simulated runoff calibrated with observed flow data of Vamsadhara, Nagavali and Sarada river basins. Vamsadhara river basin simulated runoff results as shown in figure 1 and calibrated results in figure 2. HEC HMS model output results are to be used in hydrodynamic model (HEC-RAS) to forecast the flash flood. HEC-RAS 2-D model setup, detailed hourly data collection and preparation of thematic maps under progress.

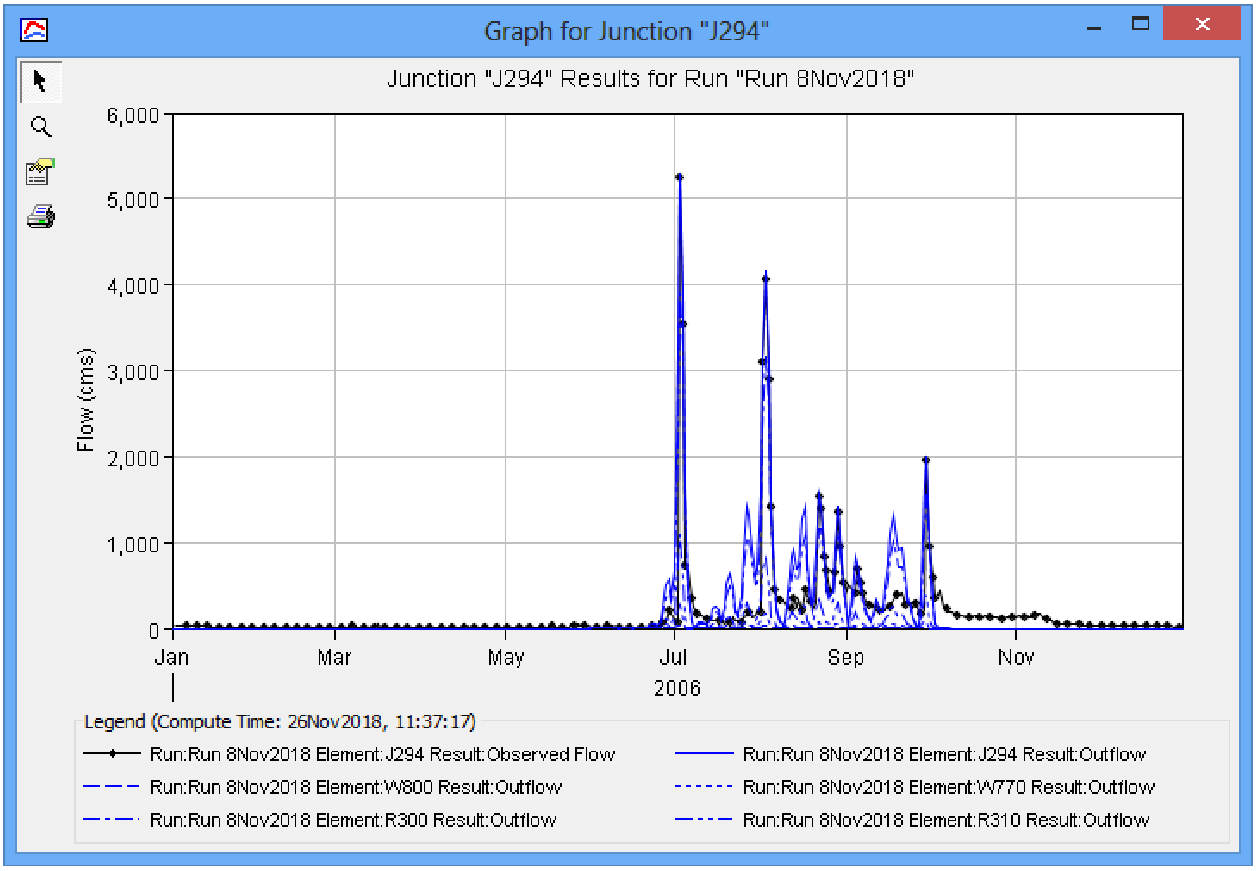


Figure 1. Model simulated runoff results at Gunupur GD of Vamasadhara river basin basin

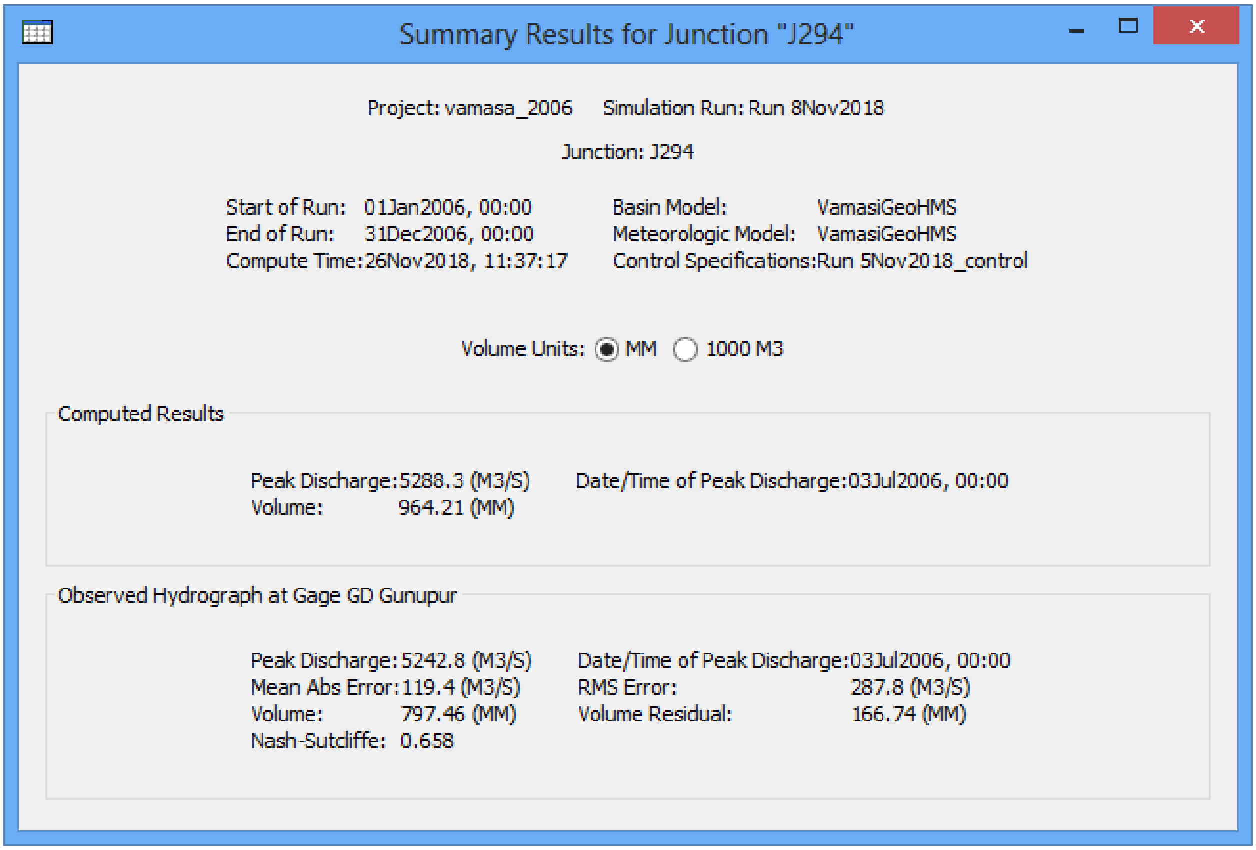


Figure 2. Model calibration at Gunupur GD of Vamasadhara river basin

CENTRE FOR FLOOD MANAGEMENT STUDIES GUWAHATI

Scientific Manpower

S N	Name	Designation
1	Dr. S K Sharma	Scientist C
2	Dr. Swapnali Barman	Scientist C
3	Mr. Gulshan Tirkey	Scientist B

Work Programme 2018-19

S.N.	Title of the Project	Team	Duration	Funding
Internal Studies				
1.NIH/CFMS-G/17-19	Estimation of Runoff for Kulsi River Basin using NRCS Curve Number and Geographic Information System	S. K. Sharma, GulshanTirkey G. Arun	Ongoing, 1 year (04/17 to 03/19)	NIH
2.NIH/CFMS-G/17-19	Evaluation of Ground Water Quality in Shillong – the Capital City of Meghalaya	C. K. Jain M. B. Ritshong S. K. Sharma Babita Sharma	Ongoing, (04/17 to 03/19)	NIH
3.NIH/CFMS-G/17-19	Morphometric Analysis of Kulsi Basin using different Digital Elevation Models (DEMs)	GulshanTirkey S. K. Sharma	Ongoing, (04/17 to 03/19)	NIH
4.NIH/CFMS-G/18-21	Flood Inundation Modelling of Beki River Basin of Assam	S. K. Sharma Rakesh Kumar Pankaj Mani J. P. Patra G. Arun	3years (04/18 to 03/21)	NIH
5.NIH/CFMS-G/18-21	Development of regional methods for design flood estimation for North Brahmaputra Subzone 2 (a)	S. K. Sharma Rakesh Kumar Pankaj Mani J. P. Patra G. Arun	3 years (04/18 to 03/21)	NIH
6.NIH/CFMS-G/18-21	Linear hydrological routing using Satellite precipitation datasets for flood forecasting in parts of Brahmaputra Basin	GulshanTirkey S. K. Sharma Pankaj Mani G. Arun	3 years (04/18 to 03/21)	NIH

1. PROJECT REFERENCE CODE: NIH/CFMS-G/17-19

a. Title of Study:	Evaluation of Ground Water Quality in Shillong – the Capital City of Meghalaya
b. Study Group:	C. K. Jain, M. B. Ritshong (SE, WRD, Meghalaya) S. K. Sharma, Babita Sharma
c. Date of Start:	April 2017
d. Duration of the Study:	Two years (April 2017 to March 2019)
e. Funding:	NIH

f. Objectives:

To examine the quality of ground water in Shilllong city of Meghalaya and suggesting remedial measures.

h. Results achieved with Progress/Present Status:

Twenty ground water samples from various abstraction sources were collected during pre- and post-monsoon seasons and analyzed for various water quality constituents (pH, EC, TDS, Alkalinity, Hardness, Sodium, Potassium, Calcium, Magnesium, Chloride, Sulphate, Nitrate, Fluoride and metal ions (Fe, Mn, Cu, Ni, Cr, Pb, Cd, Zn, As). The hydro-chemical data have been analyzed with reference to BIS and WHO standards, ionic relationships are being studied, hydro chemical facies and water types are identified. The pre-monsoon and post-monsoon samples from 2018 have been processed and maps prepared in GIS. The report is under preparation.

2. PROJECT REFERENCE CODE: NIH/CFMS-G/17-19

a. Title of Study:	Estimation of Runoff for Kulsi River Basin using NRCS Curve Number and Geographic Information System
b. Study Group:	S. K. Sharma, Gulshan Tirkey
c. Date of Start:	April 2017
d. Duration of the Study:	Two years (April 2017 to March 2019)
e. Funding:	NIH

f. Objectives:

i) To estimate runoff from Kulsi River Basin using NRCS CN Method.
ii) To prepare runoff potential maps for Kulsi River Basin.

h. Results achieved with Progress/Present Status:

Soil maps and landuse Maps for the basin have been prepared. Curve Numbers have been calculated for entire basin. Runoff Potential maps have been prepared using ArcCN Tool in ArcGIS. Study has been completed and the report is under preparation.

3. PROJECT REFERENCE CODE: NIH/CFMS-G/17-19

a. Title of Study:	Morphometric Analysis of Kulsi Basin using different Digital Elevation Models (DEMs)
b. Study Group:	Gulshan Tirkey, S. K. Sharma,
c. Date of Start:	April 2017
d. Duration of the Study:	Two year (April 2017 to March 2019)
e. Funding:	NIH

f. Objectives:

i. To analysis morphometric parameters of Kulsi Basin using different Digital Elevation Models (DEMs).
ii. To determine the effects of DEM resolution on morphology and accuracy of the streams derived from it.

h. Results achieved with Progress/Present Status:

Morphometric parameters were computed using ASTER (Advanced Spaceborne Thermal Emission and Reflection) Radiometer 30 m, SRTM (Shuttle Radar Topography Mission) 90 m and Carto DEM (Cartosat-1 Digital Elevation Model) 30 m resolution. The morphometric analysis was done in order to study overall morphology of the basin and to carry out further hydrological analysis. The study has been completed and the report is under preparation.

4. PROJECT REFERENCE CODE: NIH/CFMS-G/18-21

a. Title of Study:	Flood Inundation Modelling of Beki River Basin of Assam
b. Study Group:	S. K. Sharma, Rakesh Kumar, Pankaj Mani, Jagadish Prasad Patra, G.Arun
c. Date of Start:	April 2018
d. Duration of the Study:	Three years (April 2018 to March 2021)
e. Funding:	NIH

f. Objectives:

a. To calibrate and validate Rainfall-Runoff-Inundation (RRI) model for the Beki river basin.
b. To model rainfall-runoff process in for the Beki river basin using HEC-HMS/ NAM model.
c. To model the flood inundation in lower reach of Beki River using HEC-RAS / Mike Flood.
d. To compare the flood inundation simulations from RRI Model and HEC-RAS/ Mike Flood.

h. Results achieved with Progress/Present Status:

ASTER and SRTM DEM of 30m resolution for the study area have been downloaded and preprocessed. Flow Direction and Flow Accumulation have been derived and Watershed has been delineated. Streams have been delineated and Strahler Stream Ordering has been carried out. Geometries has been created for HEC RAS 1D and 2D flood modelling including River Centrelines, Banks, Cross Sections and 2D Mesh.

5. PROJECT REFERENCE CODE: NIH/CFMS-G/18-21

a. Title of Study:	Development of regional methods for design flood estimation in North Brahmaputra subzone 2 (a)
b. Study Group:	S. K. Sharma, Rakesh Kumar, Pankaj Mani, Jagadish Prasad Patra, G.Arun
c. Date of Start:	April 2018
d. Duration of the Study:	Three years (April 2018 to March 2021)
e. Funding:	NIH

f. Objectives:

i. Development of at-site flood frequency relationships using L-moments.
ii. Development of at-site and regional flood frequency relationships using L-moments.
iii. Development of regional relationships between mean annual peak floods and physiographic and climatic characteristics.
iv. Development of regional flood frequency relationships using L-moments.
v. Development of flood frequency relationships under climate change scenarios.

h. Results achieved with Progress/Present Status:

DEMs of 30m resolution for the study area have been downloaded and preprocessed. Catchment Area of all the North Bank Tributaries flowing in River Brahmaputra has been delineated. Basin Characteristics such as Basin Area, Longest Flow Path, Slope, Stream Order have been derived.

6. PROJECT REFERENCE CODE: NIH/CFMS-G/17-19

a. Title of Study:	Linear hydrological routing using Satellite precipitation datasets for flood forecasting in parts of Brahmaputra Basin.
b. Study Group:	Gulshan Tirkey, S.K. Sharma, P. Mani, G. Arun
c. Date of Start:	April 2018
d. Duration of the Study:	Three years (April 2018 to March 2021)
e. Funding:	NIH

f. Objectives:

i. Calibration and bias correction of satellite precipitation products (TRMM 3B42-RT, GPM IMERG & GPROF) with observed rainfall.
ii. Linear Hydrological routing of bias corrected precipitation products for runoff calculation to check the feasibility of routing using satellite precipitation products.
iii. Estimation of satellite based rainfall as well as river flows at some locations using IFAS (Integrated Flood Analysis System).

h. Results achieved with Progress/Present Status:

Catchment delineation of main tributaries for Trans boundary River Brahmaputra namely Ranga Nadi, Subanshiri, Siang (i.e., Yarlung Zangpo/Tsangpo in China), Dibang, Lohit, Buhri Dihing & Dhansiri were delineated using SRTM 30 Meter DEM. Catchment characteristics like stream length and Slope are calculated for routing purposes. Satellite rainfall products namely TRMM 3B42RT & GPM IMERG V5 Early Run Products have been plotted for various catchment grids of years 2016-2018.

7. PROJECT REFERENCE CODE: NIH/CFMS-G/17-19

a. Title of Study:	Impact of Climate Change on Runoff and Sediment Yield for a Major Tributary of River Brahmaputra
b. Study Group:	Swapnali Barman, Dr. J. V. Tyagi, R.K. Bhattacharya, Prof IIT Guwahati
c. Date of Start:	November 2018
d. Duration of the Study:	Three years (April 2018 to October 2021)
e. Funding:	NIH

f. Objectives:

i) To understand the impact of climate change on future rainfall, runoff and sediment yield of Puthimari River, a major tributary of river Brahmaputra

ii) To compare and contrast physically based SWAT model and data-driven ANN model in predicting sediment contribution of Puthimari River to the main stream Brahmaputra.

h. Results achieved with Progress/Present Status:

The Puthimari river basin has been delineated using ASTER GDEM at a horizontal spatial resolution of 30 meters in ILWIS model. Downscaled daily precipitation data with spatial resolution of 0.25 degrees (25 km x 25 km) have been downloaded for 11 different models under CMIP5 for RCP 4.5 and RCP 8.5. These 11 models are, *ACCESS1.0, BCC CSM1-1, CAN-ESM2, CCSM4, GFDL-CM3, INMCM4, IPSLCM5A-MR, MIROCC5, MPI ESM-MR, MRI-CGCM3 and NOR ESM1-M*. The trend analysis of precipitation is being performed for both historical and future projected data. Landsat data of 30m resolution have been downloaded for the years 2006, 2012 and 2018 to study the land use/land cover changes that have been taken place in the Puthimari River basin.

CENTRE FOR FLOOD MANAGEMENT STUDIES PATNA

Scientific Manpower

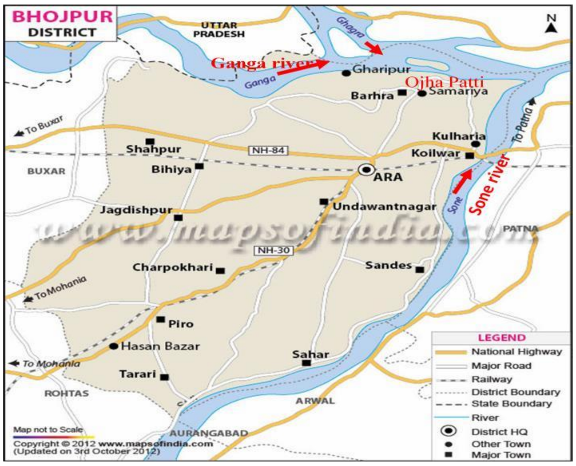
S N	Name	Designation
1	Mr.Biswajit Chakravorty	Scientist F
2	Dr.Pankaj Mani	Scientist D
3	Mr. N G Pandey	Scientist D
4	Mr. S R Kumar	Scientist D

Work program for the year 2018-2019

Sl	Title	Study Team	Duration	Funding
Internal Studies				
1.	Demonstration scheme on Riverbank Filtration in Gangetic plain of Bihar	B. Chakravorty (PI) N. G. Pandey	(02/16-03/19)	NIH
2.	Development of Relationships between Reference Evapotranspiration (ETo) of Penman-Monteith and other Climatological methods	S.R. Kumar (PI)	(04/16-03/19)	NIH
3.	River shifting analysis and flow modelling study of Ganga river from Rishikesh to Anupshahar	Pankaj Mani (PI) Rakesh Kumar, J. P. Patra	(04/16-03/19)	NIH
Sponsored Project				
1.	Water balance estimation in identified watersheds of Ranchi and Dhanbad districts of Jharkhand under NEERANCHAL watershed project	B. Chakravorty (PI) N. G. Pandey	5 years 04/17-03/22	DOLR

1. **Demonstration scheme on Riverbank Filtration (RBF) in Gangetic plain of Bihar**
B. Chakravorty (PI), N. G. Pandey (Co-PI) under overall guidance of Dr. N.C. Ghosh

In consultation with PHED, Govt. of Bihar, a site was selected at Barhara village of Ara in Bhojpur district to take up the demonstration project of RBF project. The village is bounded by the river Ganga in the north and the river Sone in the east. Ara town is the district headquarters of Bhojpur. The village has no organized drinking water supply but mostly relies on hand pumps. In and around Ara, groundwater is reported to be Arsenic affected. It is proposed to develop pilot demonstration schemes on BF on the right bank of river Ganga in Barhara village of Ara, Bhojpur district of Bihar for sustainable drinking water supply. The area is arsenic affected and therefore it is proposed to take up R&D study to see and improve natural water treatment systems.



MOU in between Head, CFMS, Patna and EE, PHED, Ara was signed on May 18, 2018. Water samples were collected from in and around the proposed drill site and analyzed. Geo-physical survey was done with Scientists from CGWB, Patna to ascertain the water bearing zone during Sept 2018.

Fund was made available to EE, PHED, Ara for execution of boring (tubewell) as deposit work for Rs. 1,00,573/- in Aug 2018. In presence of officials from PHED, Ara and NIH scientists, execution of the well drilling and the well development was done during 16-18 Feb, 2019. Apparently the well is giving good discharge and is expected to cater the need of Barhara village if found suitable which can be ascertained through regular monitoring.

The well is now ready for sample collection. A set of water samples already collected on 19 March, 2019 after continuous pumping to activate induced recharge from Ganga has been sent to NIH, Roorkee for water quality analysis.

PHED officials were also requested to lay pipe network upto 500 m with 5 HP submersible pump with pump house and few hydrant points to distribute water to village. Later on the scheme will be handed over to PHED, Govt of Bihar for maintenance and regular supply of water to the inhabitants.

2. **River shifting analysis and flow modelling study of Ganga river from Rishikesh to Anupshahar** Pankaj Mani, Rakesh Kumar, J P Patra

A study entitled "River shifting analysis, formation of sand islands and hydrodynamic flow modelling of Ganga river from Rishikesh to Anupshahar in the stretch of about 300 km is proposed with the following objectives:

- River shifting study: GIS based temporal analysis of satellite data for study of river shifting trends, identification of erosion and sedimentation prone area.
- Development of flow model: 1D flow model for the study reach, calibration and validation with observed GD data, Inundation mapping-validation with satellite data, Inundation maps for floods of different return period.
- Development of 2D morphological model for the area.

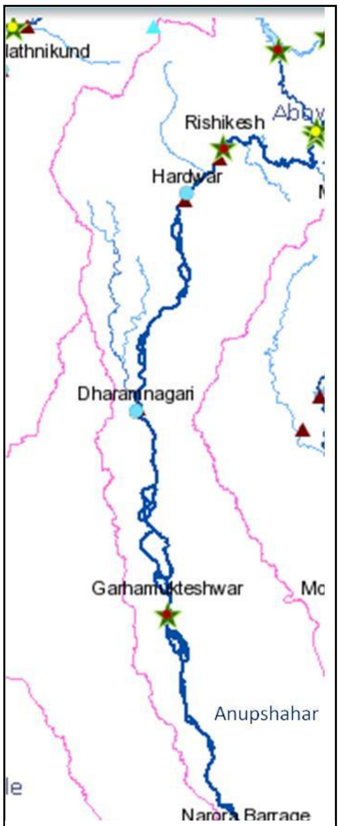
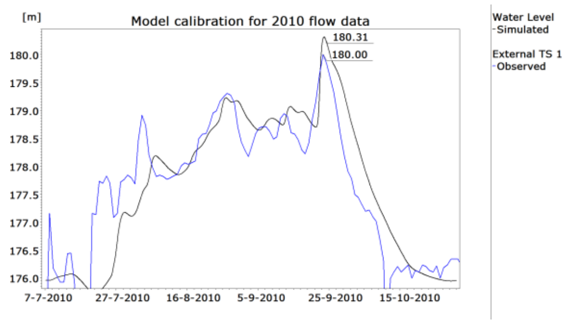


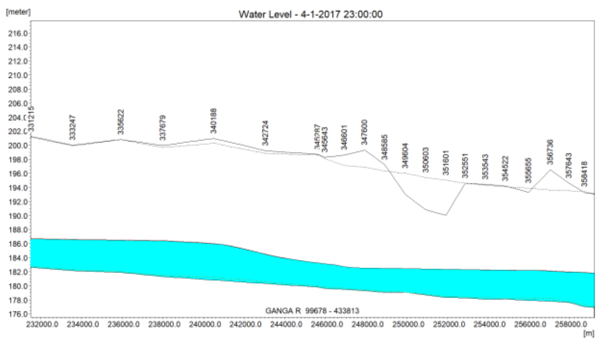
Figure 5: Study Area

Anupshahar is facing continuous erosion threat on the right bank of river Ganga. Study of geomorphological characteristics is important for planning the river training work for protection of the area. The hydrodynamic (HD) modelling of the river provides the water surface profile needed for design of flood protection works (embankment etc.). In addition, 2D morphological modelling of the river stretch helps in understanding the long and short term impact of river training works in the hydraulic regime of the river.
For this reach of the river geomorphological study and identification of erosion/ silting prone area, the IRS satellite data are being used. The entire study stretch is covered in four scenes of LISS III data. At the affected sites, detailed analysis is being carried out using high resolution satellite data (LISS IV). Over the duration of nineteen years from 1997 to 2015 data of five time periods viz. 1997, 2000, 2006, 2011 and 2015 have been procured from NRSC, Hyderabad. Further, silt balance study is also proposed to be carried out between Rishikesh to Kachhala Bridge site.

HD Model in MIKE 11- For the flow model study, 103 surveyed river cross sections between Rishikesh to Kachhalabridge (stretch of 334 km) have been used. Also, from Tehri dam site to Rishikesh (99.7 km stretch), 14 river cross-sections have been extracted from online CartoDEM (available from Bhuvan website of NRSC). In addition, 30 digital toposheets have been procured from SOI and DEM has been prepared for the river reach. Hydrological data of the four gauging sites viz. Rishikesh, Gurumukteshwar, Narora and Kachhalabridge have been procured from CWC. Flood frequency analysis has been carried out using the annual maximum flood data of the gauging sites and floods of various return periods have been estimated. MIKE 11 HD package is used for estimating river discharge, velocity, depth, duration and inundation for the study stretch.

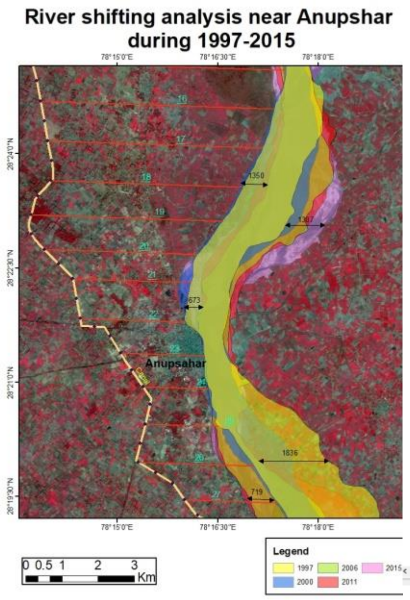
2D Morphological modelling- The bathymetry of the river bed is prepared from the river cross section survey data. The curvilinear grids have been developed for the river reach between Garhmukteshwar to Kachalabridge. The MIKE 21C model has been developed and calibrated with 2013 discharge (at Narora site) and silt data (at Kachalabridge site). Further, 100 year flood has been simulated to estimate the maximum flood depth, velocity and silt concentration near Anupshahar.

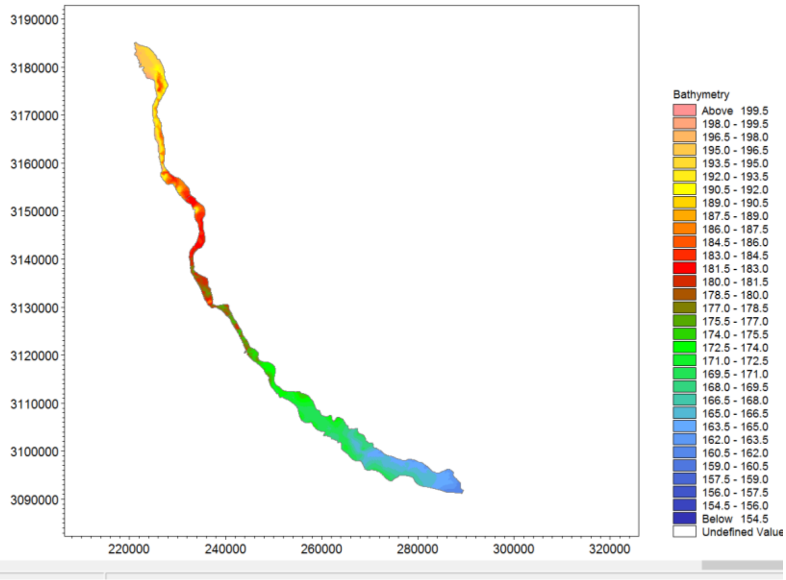




Calibration of MIKE 11 Model with 2010 flow data

Water Surface Profile near Anupsahar for 100 year return period flood





Shifting of Ganga river near Anupsahar using temporal satellite images

Development of curvilinear grid for MIKE 21C flow model

APPENDIX 72.4.2

LIST OF PAPERS PUBLISHED/ ACCEPTED FOR PUBLICATION DURING APRIL, 2018 – MARCH, 2019

LIST OF RESEARCH PUBLICATIONS FROM APRIL 2018 TO MARCH, 2019

S.No.	Item	Published
1.	International Journal	52
2.	National Journal	25
3.	International Conference/ Seminar/ Symposium	61
4.	National Conference/ Seminar/ Symposium	12
5.	Books/Chapters	10
	Total	**160**

Book Chapters

1.	Chakravorty, B. and Ghosh, N.C. (2018). "A Study of the Characteristics of Groundwater Solute Transport Parameters". As a book chapter in the book entitled "groundwater" by Springer-Nature under the Water Science and Technology Library, 76, ISBN 978-981-10-5788-5, pp 195-209
2.	Goel M.K. Chapter 02 on Water, Snow, and Ice including Glaciers Submitted the revised Chapter 02 on Water, Snow, and Ice including Glaciers to the DST for the Health status of the Himalayas. India.
3.	Kumar, Sudhir "Environmental Isotopes in Groundwater Applications." In Groundwater Development and Management, pp. 77-146. Springer, Cham, 2019.
4.	Pandey, Rajendra Prasad, Rakesh Kumar and D. Tsegai (2018). Integrating regional climate and drought characteristics for effective assessment and mitigation of droughts in India. Chapter accepted for publication in book entitled "Drought preparedness and livelihood implications in developing countries: What are the options", (Editors: Everisto Mapedza, Daniel Tsegai, Michael Bruentrup and Robert McLeman) to be published by IWMI and UNCCD.
5.	Qazi, Nuzhat Q., Sharad K. Jain, Renoj, J. Thayyen, Pravin R. Patil and Mritunjay K. Singh Hydrology of the Himalayas, In: Himalayan Weather and Climate and their impact on the Environment (Eds.) A.P Dimri, Bookhagen, Stoffel and Yasunari, Springer.
6.	Singh, R., Singh, O., Goyal, V. C., Singh, N. (2018). Root zone wastewater treatment for rejuvenatıng vıllage ponds. In: Indo-US Bilateral Workshop on Water-Food-Energy-Climate Nexus: A Perspective towards Sustainable Future (Eds. Singh R. P., Kolok A. S., Bartlet-Hunt S. L.), K. R. Publishers & Distributors, Varanasi (ISBN: 978-93-88179-09-6), 23-26.
7.	Singh, Rajesh, Omkar Singh, V. C. Goyal, Nihal Singh (2018) "Root zone wastewater treatment for rejuvenatıng vıllage ponds", Book Chapter of Indo-US Bilateral Workshop on Water-Food-Energy-Climate nexus: A perspective towards a sustainable Future, pp. 23-26, K.R. Publishers & Distributors, Varanasi, 05ISBN-978-93-88179-09-6, First Edition-2018.
8.	Shekhar, S., Kumar, S., Sinha, R., Gupta, S., Densmore, A., Rai, S.P., Kumar, M., Singh, A., Van Dijk, W., Joshi, S. and Mason, P. Efficient Conjunctive Use of Surface and Groundwater Can Prevent Seasonal Death of Non-Glacial Linked Rivers in Groundwater Stressed Areas. In Clean and Sustainable Groundwater in India (pp. 117-124). Springer, Singapore, 2018.
9.	Thayyen, Renoj J., HimanikalennaOzhukunnaHimakkattakal, Shastrakeralm, January, 2019. (In Malayalam).
10.	Thayyen, R.J (In Press): Hydrology of the Cold-arid Himalaya. In: Himalayan Weather and Climate and their impact on the Environment (Eds.) A.P Dimri, Bookhagen, Stoffel and Yasunari, Springer

International Journals

1	Akhtar, Naseem, S P Rai, Ravi Saini, Neeraj Pant. 2018. A Comparative Study of Water Quality of Groundwater in Garautha Block, Jhansi District, Uttar Pradesh, India International Journal of Research in Advent Technology, Vol.6, No.9, September 2018 E-ISSN: 2321-9637 Available online at www.ijrat.org 2404
2	Dularchand Chaudhary, Dinesh Kumar, R.K. Jaiswal and A.K. Nema "A Statistical Downscaling Technique for Assessment of Meteological Parameters under Climate Change Condition Using SDSM-DC Model in Raipur District". International Journal of Bio-resource

	and Stress Management 2018, 9(4),489-498. DOI:HTTP://DOI.ORG/10.23910/IJBSM /2018.9.4.3C0268.
3	Debnath, P, Das, Kousik, Mukherjee, Abhijit, Ghosh, N.C., Rao, Someshwar, Kumar, Sudhir, Krishan, Gopal, Joshi, Gopal. "Seasonal-to-diurnal scale isotopic signatures of tidally-influenced submarine groundwater discharge to the Bay of Bengal: Control of hydrological cycle on tropical oceans". Journal of Hydrology. 571: 697-710, 2019.
4	Goyal, V C, T Thomas, S Goyal and R V Kale (2018). Water supply-demand assessment in Ur river watershed in Tikamgarh district, In: V P Singh et al.(Eds.), Water resources managemet, Water Science & technology Library 78, Springer Nature, https://doi.org/10.1007/978-981-10-5711-3_21.
5	Gupta, Meeta, V C Goyal, Fawzia Tarannum, Jyoti P Patil (2017). Designing a watershed scorecard as a performance evaluation tool for Ur river watershed, Tikamgarh district, Madhya Pradesh, International Soil and Water Conservation Research, 5 (2017), 280-292. https://doi.org/10.1016/j.iswcr.2017.10.001.
6	Gupta, SK., Tyagi, JV, Singh, PK., Sharma, G., and Jethoo, AS. (2019). Soil Moisture Accounting (SMA) Based Sediment Graph Models for Small Watersheds. Journal of Hydrology, HYDROL29284R1.
7	Gurjar, Suman, Narayan C. Ghosh, Sumant Kumar, Anupma Sharma and Surjeet Singh. "Process Based Integrated Models for Managed Aquifer Recharge and Aquifer Storage Treatment and Recovery", Water Resources Management: An International Journal, European Water Resources Association (EWRA), 33(1): 387-400, 2019.
8	Hailu Birara, R. P. Pandey, S. K. Mishra, "Trend and variability analysis of rainfall and temperature in the Tana basin region, Ethiopia", Journal of Water and Climate Change, Publisher International Water Association (IWA), Published Online May 2018, jwc 2018080; DOI: 10.2166/wcc.2018.080.
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31.	Mani, Pankaj, Rakesh Kumar, J P Patra, “Dam Break Flood Hazard Mapping Using CartoDEM Data in a Hilly Terrain” Presented paper at HYDRO 2018 INTERNATIONAL (Hydraulics, Water Resources and Coastal Engineering) organised at National Institute of Technology Patna, Bihar, India during 19 21 December 2018, Patna
32.	Mani, Pankaj, Rakesh Kumar, J.P. Patra, ‘Dam Break Analysis of Chamera II dam using MIKE 11 model International Dam Safety Conference 13 14 February 2018 Bhubaneswar Organized by CWC, Odisha WRD and the World Bank India bhubaneswar
33.	Nayak, T.R. (2019) “Impact of Land use Changes on Sedimentation in Sagar Lake”. International Conferences on Multi-Disciplinary Approach towards Sustainable Development (Role of Government, Civil Societies and Citizens) during 21-22 February, 2019 Organized by India Institute of Forest Management Bhopal (MP), India.
34.	Nema, M K, Sharad Kumar Jain, Deepak Khare, “Assessment of ecological status of a river by using the eco flow metrics”, Paper presented in 23rd International Conference on Hydraulics, Water
35.	Patra, J.P., Rakesh Kumar, Pankaj Mani, (2018), “Hydrologic and Hydraulic Modelling of a Bridge” In HYDRO 2018 INTERNATIONAL (Hydraulics, Water Resources and Coastal Engineering) organised at National Institute of Technology Patna, Bihar, India during 19 21 December 2018.
36.	Pandey, R.P., Rakesh Kumar, ‘Regional Drought Characteristics and Challenges of Water Management in India, Regional Drought Characteristics and Challenges of Water Management in India. Ist International Conference on Sustainable Water Management, Organized under National Hydrology Project (NHP), 10 11 Dec. 2018 at Chandigarh, India. India Chandigarh from:01 Dec 2018 to 31 Dec 2018 Month: Dec 2018
37.	Purandara, B.K., Venkatesh,B., and Tyagi, J.V., Simulation of Soil moisture movement and solute transport characteristics in parts of Malaprabha catchment, Proceedings of Hydro-2018 India-Patna from:19 Dec 2018 to 21 Dec 2018
38.	K.N.V. Rama Devi, R. VenkataRamana, Y. R. SatyajiRaoand Sanjeetkumar(2019). “Development of Data Driven Rainfall-Runoff Model for the Sarada River Basin 2nd International Conference on Advances in Civil Engineering(ICACE-2019)”, 21st to 23rd March 2019, Organized by Department of Civil Engineering KoneruLakshmaiah Education Foundation (K L Deemed to be University), Vaddeswaram-, A.P.
39.	Ranade, Ashwini, “A study of 16 17 June 2013 Uttrakhand Heavy Rain Event using Equatorially/Globally Conditioned Meteorological Analysis”, HYDRO 2018 International Conference at NIT Patna during Dec 19 to 21 Dec 2018

40.	Rathore, D.S., M.K. Goel, R.P.Pandey, Sanjay Kumar, Surjeet Singh, 'Water Resources Planning for Upper Bhima Basin upto Ujjaini', International Conference on Sustainable Water Management organized by Bhakra Beas Management Board under NHP (MoWR, RD & GR). India Chandigarh from 10 to 11 Dec 2018.
41.	Rawat, S. S., P. G. Jose, S. P. Rai and N. Hakhoo (2018) Spring Sanctuary Development: Sustaining Water Security in The Himalayan Region in Changing Climate. International Conference on "Water Environment and Climate Change: Knowledge sharing and Partnership" organize by Dept. of Water Supply and Sewerage, Govt. of Nepal; Society of Public Health Engineering, Nepal; and Nepal Engineers Association during April 10-12, 2018 at Kathmandu, Nepal.
42.	Sharma, M. K., Thayyen, R. J., Jain, C. K., Arora, M. and Shyamlal. 2018. Seasonal variations of major ion chemistry and solute fluxes of meltwater of River Bhagirathi, a Himalayan tributary, India. In: Abstract Souvenir of 23rd International Conference on "Hydraulics, Water Resources and Coastal Engineering (HYDRO 2018 International)", Dec. 19-21, 2018 at NIT, Patna.
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44.	Saha A., Patil M., Karwariya S., Pingale S.M., Azmi S., Goyal V.C., Rathore D.S. (2018) Identification of potential sites for water harvesting structures using geospatial techniques and multi-criteria decision analysis. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-5, 2018 ISPRS TC V Mid-term Symposium "Geospatial Technology – Pixel to People", 20–23 November 2018, Dehradun, India.
45.	Singh, R. and Rai, S. P. 2019. Hydrochemical characteristics of river Ganga in head water region between Gangotri and Haridwar, Uttarakhand, India. In: Proceedings of International Conference on "River Health: Assessment to Restoration", Feb 14
46.	Singh, A., Tripathi, V. K., Kumar, P. and Singh, R.M. 2019. Role of environmental flow in river restoration. In: Proceedings of International Conference on "River Health: Assessment to Restoration", Feb 14
47.	Manjunatha Swamy,M.A., Hiremath.C.G And Venkatesh.B., Impacts Of Climate Change On River Flow: A Case Study On Thunga River Basin Karnataka, Proceedings of Hydro-2018 India-Patna from:19 Dec 2018 to 21 Dec 2018
48.	Thayyen, R. J. (2018), "Characterising different hydrological regimes of Upper Indus Basin", 3rd Indus Basin Knowledge Forum (IBKF) and scenario Workshop to be held at Vienna, Austria from 31th May to 2nd June 2018.
49.	Thakur, A., Nema, A.K., and Mishra, P.K. (2019). Trend analysis of temperature for the Wainganga sub-basin, India, proceeding of the 53rd Annual Convention of Indian Society of Agricultural Engineers and International Symposium on "Engineering Technologies for Precision and Climate Smart Agriculture" during January 28-30, 2019 jointly organized by ISAE and Institute of Agricultural Sciences, Banaras Hindu University (BHU) at Banaras.
50.	Thakur, A., Nema, A.K., Mishra, P.K. and Sahoo, S.P. (2019). Temporal precipitation variation for the Wainganga sub-basin, proceeding of the International Symposium on "Advances in Agrometeorology for Managing Climatic Risks of Farmers (INAGMET-2019)" during February 11-13, 2019 organized by Association of Agrometerologists at New Delhi.
51.	Thayyen, Renoj J. "Integrated Solutions for Water, Energy, and Land (ISWEL), Indus basin Scenario Development workshop" workshop organised by Institute for Applied Systems Analysis (IIASA),at Vienna, Austria 29-30 May 2018.
52.	Thomas, T., Ghosh, N. C., Sudheer, K. P. and Gunthe, S. S. (2019). Detection of Possible Climate Change Signals in the Historical Climate Datasets – A Case Study for Narmada Basin, International Conference on Multi-Disciplinary Approach towards Sustainable Development: Role of Government, Academicians, Corporate, Civil Societies and Citizens (Anusandhan 2019) during 21-22 February 2019 at IIFM, Bhopal (abstract published).
53.	Tiwari, Dipti, Ajay Ahirwar and Anupma Sharma. "Simulation of Rainfall-Runoff Process Using HEC-HMS model for Ungauged Catchment", Proc. 5th International Conference on Hydrology and Watershed Management, JNTUH Institute of Science and Technology, Hyderabad, 12-15 February 2019, p. 358 -365.
54.	Tripathi R., Pingale S.M., Khare D. (2019) Assessment of LULC change and urban water demand

	for sustainable water management: A case study of Dehradun city. International Conference on Smart City Model (ICSCM 2019) at IIT Madras from 20 to 21 January 2019.
55.	Trivedi, A., Pyasi, S.K. and Galkate, R.V. (2018) Assessment of Impact of Climate Change using RRL AWBM Model. Water and Energy International, ISSN 0974-4711,Volume 61, RNI No. 9, pp. 51-59.
56.	Venkatesh, B., B.K. Purandra, 'Assessing the hydrological services provided by a forested basin in Western Ghats, Karnataka, India, International Conference on HYDRO-18, NIT, Patna, Dec 19-21, 2018.
57.	Venkatesh, B., B.K. Purandra, 'Spatio-temporal analysis of Soil Moisture under various Land Covers- A case Study from Western Ghats, India,' Intrnational Conference on "Global Water Security Conference for Agriculture and Natural Resources, Hyderabad from Oct. 3-6, 2018.
58.	R. VenkataRamana, Y R SatyajiRao, V.S.Jeyakanthan and T Vijay (2019), 'Urban Flood Management in Greater Hyderabad Municipal Corporation City (Zone XII) using GSI and SWMM, Proceedings of the 5th International Conference on Hydrology and Watershed Management with a focal theme on Urban Water Management for Sustanable Development , held at JNTU, Hyderabad, during 12th -15th February 2019.
59.	R. VenkataRamana, Y R SatyajiRao, V.S.Jeyakanthan and T Vijay (2019), 'Time Series Flash Flood Forecasting using Stochastic and Hybrid Mode', Proceedings of the 5th International Conference on Hydrology and Watershed Management with a focal theme on Urban Water Management for Sustanable Development , held at JNTU, Hyderabad, during 12th -15th February 2019.
60.	Wani, John Mohd., Renoj J. Thayyen, C.S.P. Ojha, Stephan Gruber, 'Frozen ground in the cold-arid Himalaya: a case study from Upper Ganglass catchment, Leh-EUCOP- June 2018.
61.	Wani, John Mohd, Renoj J. Thayyen, Chandra Shekhar Prasad Ojha, and Stephan Gruber (2018): Inferring permafrost occurrence from surface energy balance and miniature temperature data (MTD) loggers in Cold Arid Himalaya, Geophysical Research Abstracts Vol. 20, EGU2018 11929, 2018.

National Conference

1.	Ch.GouseSandhani**,** SatyajiRao, YRS, T.Vijay and B.ChaitanyaRao, 'Evaluation of Godavari River Water Quality and Dissolved Oxygen SAG Curve Analysis', Proceedings of the National conference on Emerging Trends in Water Quantity and Quality Management –II (ETWQQM-2019) held at Poornima University, Jaipur during 29th-30th March 2019.
2.	Kumar, S.R. (2018). Groundwater Quality Modelling for Irrigation Appraisal (Paper ID-409 page no.-733 ISBN No:978-93-5291-653-5) (National Conf. on 13th Session of J&K Science Congress (April 02-04, 2018). Paper presented.
3.	J. Ravi Kiran and S.R. Kumar (2018). Groundwater Quality Scenario Evaluation Using Graphical Classification Methodologies (paper ID-408, page no.-872 ISBN No: 978-93-5291-653-5 in National Conf. on 13th Session of J&K Science Congress (April 02-04, 2018). Paper presented.
4.	Ranade, Ashwini, "Equatorially/ Globally Conditioned Atmospheric Analysis to Monitor Evolution of Monsoon and Indian Monsoon 5th Bharatiya Vigyan Sammlan ', held during 11-14 May 2017, Fergusson College, Pune. India
5.	Ranade, Ashwini, "Evolution of Monsoon and Mind Through Veda, Arya, Bharat, Indu, Sindhu and Hindu Ages 5th Bharatiya Vigyan Sammlan ', held during 11-14May 2017, Fergusson College, Pune.
6.	Patra, Jagdish Prasad, Rakesh Kumar, Pankaj Mani, 'Flood Hazard Assessment for a Dam Failure', Awarded best (First) presentation in the Sun-theme area of Water Quantity-Water Resources Management in the National Conference On Emerging Trends In Water Quantity & Quality Management (ETWQQM-2019) organised at Poornima University, Jaipur During 29-30 March 2019.
7.	Patra, J.P., 'Nalgad dam and reservoir simulation using HEC-RESSIM model for hydropower generation', National Conference on Emerging Trends in Water Quantity & Quality Management (ETWQQM-2019) at Poornima University, Jaipur during 29-30 March 2019.
8.	Mangal, S.C. & P.K. Agarwal (2019),"जल के इष्टतम उपयोग में प्रबंधन की भूमका", Paper

	accepted for ongoing national conference in NWDA, Hyderabad, 14-15 June 2019 India-Hyderabad
9.	Manohar Arora. Uncertainties in climate change projections. National Conference on Emerging Trends in Water Quantity and Quality, Jaipur. Accepted.
10	Mir, Riyaz, Sanjay K Jain and A K Lohani, Paper Expansion of a glacial lake and simulation of its outburst floods using an integrated approach of remote sensing, GIS and dam break modelling, National Interdisciplinary Science Conference on Science in Development, 3-4 December, 2018 at Dept. of Env. & Water Management, Sri Pratap College, Srinagar
11	Sk.Md. Allabakshi, SatyajiRao, YR, T Vijay and B.ChaitanyaRao, 'Reduction of Concentration of RO Rejects on Soil and Aquifer using RHAFM, Proceedings of the National conference Emerging Trends in Water Quantity and Quality Management-II (ETWQQM 2019), held at Poornima University, Jaipur, during 29th -30th March 2019.
12	SatyajiRao, Y.R (2019). Modeling Impact of Faulty Septic Systems using RISK-N Model. Published in the proceedings of All India Seminar on "Water and Sanitation Management" held at VisvesvarayaBhawan, Khairatababd, Hyderabad during March19-20, pp. 20-29

APPENDIX 72.4.3

LIST OF WORKSHOPS/ TRAINING COURSES/ SYMPOSIA ORGANISED DURING APRIL, 2018 – MARCH, 2019

S.No.	Name of Course	Period	Venue
1.	Inception Workshop on ‘Modelling of Tawa Reservoir Catchment and Development of Tawa Reservoir Operation Policy under NHP-PDS’	May 2, 2018	Tawa resort Tawanagar, itarsi
2.	One day Consultation Workshop on ‘IWRM based water security plan for 4 district of Bundelkhand’	May 25, 2018	Tikamgarh, M.P.
3.	Training Course on “Hydrologic Modelling using SWAT”	June 11-22, 2018	Roorkee
4.	UNDP sponsored International Training Course on “Hydrology, Water Resources Management and Climate Change” for the participants of Pacific Island Countries	June 25-20 July, 2018	Roorkee
5.	Training Workshop on “Reservoir simulation using NIH_ReSyP”	June 25-29, 2018	BITS, Pilani, Hyderabad campus
6.	One day Stakeholders Workshop for DST sponsored Networking Project on ‘Revival of Village Ponds through Scientific Interventions’	July 13, 2018	Banda Block, Sagar
7.	Workshop on “DSS(H): Demonstration of Modules”	July 20, 2018	TPSIPRD, Nimora, Raipur Chhattisgarh
8.	Workshop under NNWP on ‘DSS(H): Demonstration of the modules’	July 20-21, 2018	Raipur
9.	Inception Workshop on ‘Ground water Salinity Source Identification in Godavari Delta, Andhra Pradesh’ under PDS-NHP	July 25, 2018	Kakinada
10.	Training course on ‘Basics of Hydrology’ under NHP	July 23-27, 2018	NIH, Bhopal
11.	A 04-day training course on “Overview of Water Resources Sector” organized for Non-Technical officers of Ministry of MOWR, RD & GR during 6-9 August, 2018.	Aug. 6-9, 2018	NIH, Roorkee
12.	Training on “Hydrological modeling using HEC RAS and HEC HMS”	August 27-31, 2018	NIH, Roorkee
13.	Training Workshop on ‘Ground Water Modelling’	Sept. 4-6, 2018	WALMI Bhopal
14.	National Inception workshop on State Specific Action Plan (SSAP) for Water Sector	Sept. 14, 2018	Pune
15.	Modellers Meet under NHP	Sept.26-27, 2018	New Delhi
16.	Organized R & D Session of INCCC at MoWR RG & GR, New Delhi	Sept. 27, 2018	New Delhi
17.	Training Course on ‘Environmental Isotopes for Climate Resiliency of Mountain Watersheds’	Oct.22-26, 2018	NIH, Roorkee
18.	Training Course on ‘Estimation of Flood and Yield’	Nov.11-16, 2018	Nashik
19.	UNESCO sponsored Training Course on “IWRM, Water Security and Climate Change for Developing Economies”	Nov.15-16, 2018	NIH, Roorkee
20.	Brain Storming Session on ““Water and Human Settlements of the Future” during HYDRO-2018 INTERNATIONAL	Dec. 21, 2018	NIT Patna
21.	Three Days Training Course on “Water Conservation: Practices, Security and Sustainability- A Practitioners Approach”	Dec.26-28, 2018	NIH, Roorkee
22.	Training Workshop on “River Basin Modelling”	Jan. 07-11, 2019	SIHFW, Jaipur
23.	Three Days Training Course on “Water Conservation:	Jan. 14-16,	NIH, Roorkee

	Practices, Security and Sustainability- A Practitioners Approach”	2019	
24.	Customized Training Course on ‘Groundwater Flow Modelling using MODFLOW’	Jan. 14-18, 2019	Kerala
25.	Training Course on “Flood and Drought Risk Management”	Jan. 21-25, 2019	NIH, Roorkee
26.	Training Course on “Water Security: Best Practices for Conservation, Safety and Sustainability”	Jan. 23-25, 2019	WHRC, Jammu
27.	Workshop on “MS-Office, Computer Awareness and Internet Usage for the Institute Staff”	Jan. 28, 2019	NIH, Roorkee
28.	On Site training on DSpace Software	Feb. 11-15, 2019	NIH Roorkee
29.	Training programme on “Water Quality Monitoring of Surface, Ground, Waste Water / Effluent, Data Interpretation and Quality Assurance” sponsored by CPCB	Feb. 11-13, 2019	NIH Roorkee
30.	Training Course on ‘Coastal Zone Water Resources: Challenges, Investigation Techniques and Management’	Feb. 11-15, 2019	NIH, Roorkee
31.	Training Course on Conservation and Management of Lakes,Wetlands And Springs	Feb. 25-Mar. 1, 2019	NIH Roorkee
32.	Training Course on “Sediment Yield and Reservoir Sedimentation”	Feb.25-Mar.1, 2019	NIH Roorkee
33.	Training Course on “Advanced Hydrology”	Mar. 5-9, 2019	NIH Roorkee
34.	One day Workshop on ‘High Performance advanced Septic system (HPAS) for Villages and Roadside Restaurants’ under IC-IMPACTS (Indooooo Canada Project)	Mar. 15, 2019	Kakinada
35.	Brain Storming Session on ‘Water for All by 2030: Leaving no one behind’	Mar. 22, 2019	NIH, Roorkee
36.	First Stakeholder Workshop on the PDS under NHP titled “Impact Assessment of the upcoming Irrigation Projects and Climate change on the Drought and Densification Scenario for Chambal Basin in Western M.P.	Mar. 27, 2019	State Water Data Centre, Bhopal

APPENDIX 72.4.4

PROGRESS OF LABORATORY WORK DURING THE PERIOD APRIL, 2018 – MARCH, 2019

1. Nuclear Hydrology Laboratory
2. Water Quality Laboratory
3. Soil-Water Laboratory

Details of samples analysed in Nuclear Hydrology Laboratory

S.N.	Parameter analysed	No. of samples
1	δ^2H on DI-IRMS	6996
2	$\delta^{18}O$ on DI-IRMS	919
3	$\delta^{18}O$ on CF-IRMS	5653
4	Tritium	310
5	WQ samples on IC	950

Chemical and Bacteriological Analysis of Water Samples in Water Quality Laboratory

	No. of samples of Division	No. of samples of Regional Centre	No. of samples of Outside Agencies on payment basis
Physico-chemical analysis	1290	-	-
Bacteriological analysis	36	-	-
Metal analysis	-	-	-
Pesticide analysis	-	-	-
Total analysis	1326	-	-

Soil Water Laboratory

Laboratory Analysis carried out during the period April 2018 to March 2019

Sl. No.	Name of the Study	No. of Samples	Parameters Measured
1.	Water Availability and Water Budgeting of Kalsi Micro-Watershed, Uttarakhand	Nine (09)	1. Determination of soil texture using sieve shaker and laser based particle size analyzer.
2.	DMRC Metro Transect Project at Noida (U.P.)	Thirty Four (34)	1. Determination of soil texture using sieve shaker and laser based particle size analyzer. 2. Determination of soil moisture retention characteristics by disturbed soil samples. 3. Determination of Bulk Density. 4. Determination of soil moisture of undisturbed soil sample. 5. Determination of pH and EC.
3.	Plot-scale hydrology of Lesser Himalayan Watershed (IIT Roorkee)	Six (06) + Twenty Seven (27)	1. Determination of soil texture using sieve shaker and laser based particle size analyzer (6 Samples). 2. Determination of Bulk Density (27 samples)
4.	Peya Jal Suraksha, Agra (U.P.) Water Works Campus	Twenty Three (33)	1. Determination of soil moisture retention characteristics by Pressure Plate Apparatus.
5.	Water table investigations and ascertaining its fluctuations and levels in stretch from chainage 59+600 m to 67+300 m in Rewari to Dadri of CTP 14 package of dedicated freight corridor project	Twenty Seven (27)	1. Determination of soil texture using sieve shaker and laser based particle size analyzer.
6.	Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin upto Delhi (NHP)	Fourteen (14) + Twelve (12)	1. Determination of soil moisture. (26 Samples) 2. Determination of soil texture using sieve shaker. (26 Samples) 3. Determination of soil texture using laser based particle size analyzer. (14 Samples) 4. Determination of in-situ saturated hydraulic conductivity using Guelph Permeameter on eight sites. 5. Determination of infiltration using Infiltrometer on eight sites.

7.	Impact of Rain Water Harvesting on Groundwater Quality in India with Specific Reference to Fluoride and Other Micro-pollutants (Indo-UK DST-NERC Project under Newton Bhabha Fund)	One Hundred Fourteen (114)	1. Determination of soil texture using sieve shaker and laser based particle size analyzer (114 Samples). 2. Determination of soil moisture retention characteristics by disturbed soil samples (76 Samples). 3. Determination of Permeability using ICW Lab Permeameter (28 Undisturbed Soil Samples). 4. Determination of Bulk Density (50 Undisturbed Soil Samples). 5. Determination of soil moisture (28 Undisturbed Soil Samples) 6. Determination of Specific Gravity (28 Undisturbed Soil Samples).
8.	Estimation of Groundwater Recharge using Numerical Modeling (NIT Patna MTech Student)	Seven (07)	1. Determination of soil texture using sieve shaker and laser based particle size analyzer. 2. Determination of Infiltration and saturated Hydraulic Conductivity of both Bareland and Grass covered land. 3. Determination of soil moisture retention characteristics by disturbed soil samples (7 Samples). 4. Monitoring of soil moisture using Tensiometer and Soil Moisture Sensor installed at different depth.
9.	Integrated Water Resources Management (IWRM) of Pond Area (MOWR, RD&GR Project)	Thirty Two (32)	5. Determination of soil texture using sieve shaker (27 Samples). 6. Determination of Permeability using ICW Lab Permeameter (32 Undisturbed Samples). 7. Determination of Bulk Density (32 Undisturbed Samples). 8. Determination of soil moisture (32 Undisturbed Samples).
10.	Ganges Aquifer Management in the Context of Monsoon Runoff Conservation for Sustainable River Ecosystem Services- A Pilot Study (NHP)	Eighty Nine (89)	1. Determination of soil texture using sieve shaker (89 Samples). 2. Determination of Permeability using ICW Lab Permeameter (55 Undisturbed Samples). 3. Determination of Bulk Density (55 Undisturbed Samples). 4. Determination of soil moisture (55 Undisturbed Samples).

11.	A Study on Geo–environmental Pollution due to Pesticide Use in Agriculture (IIT Delhi PhD Scholar)	Twenty	1. Determination of soil texture using sieve shaker and laser based particle size analyzer. 2. Determination of soil moisture retention characteristics by disturbed soil samples.
12.	Sustainable Urban Storm Water Management. Storm Runoff Sample during August-Sept 2018 (IIT Roorkee PhD Scholar)	Eleven (11)	1. Determination of soil texture using laser based particle size analyzer.

APPENDIX 72.4.5

LIST OF ACTIVITIES UNDER IEC SCHEME ORGANISED DURING APRIL, 2018 – MARCH, 2019

LIST OF ACTIVITIES UNDER IEC SCHEME

S.No.	Activities	Organised by & Date
1.	One day mass awareness on "Earth Day 2018 : End Plastic Pollution"	22 April, 2018 at NIH WALMI Campus, Patna
2.	Awareness Program on 'River Bank Filtration' organised in association with TERI, Goa	29 may, 2018 at Belagavi
3.	"World Environment Day 2018: Beat Plastic Pollution"	5 June, 2018 at CFMS, Patna
4.	Mass Awareness Program on 'water Resources Management'	20th July, 2018 at ZP High School, Kandregula
5.	हिंदीमास	अगस्त 15 से सतम्बर 14, 2018, रा. ज. स., रुड़की
6.	हिंदीसप्ताह	सतम्बर 8 से 14, 2018 पश्चिम हिमालय क्षेत्रीय केंद्र - जम्मू
7.	Swachh hi Seva Campaign under Swachh Bharat Mission	15th Sept. to 2nd Oct. 2018 at CFMS, Patna
8.	Cleaning of residential socities under Swachhta hi sewa campaign	25 Sept., 2018 at Bhopal
9.	Cleanliness of NIH office complex and NIH residential colony	25 September-02 October, 2018
10.	Cleaning activities: Division /Units / Labs	25 September-02 October, 2018
11.	Cleaning of Ghat and plantation	28 September, 2018
12.	Cleanliness of NIH residential colony	29 September, 2018
13.	Vigilance Awareness Week with Integrity pledge, Quiz competition and a seminar on 'Organisations and Inetruments to eradicate corruption'	29 Oct. – 2 Nov., 2018 at WHRS, Jammu
14.	Brainstorming session cum mass awareness under theme *"Eradicate Corruption-Build a New India"* under Vigilance Awareness Week	29th Oct – 3 Nov., 2018 at CFMS, Patna
15.	Vigilance Awareness Week	30th October - 4th November, 2018 at NIH, Roorkee
16.	जल जागरूकता कार्यक्रम	केन्द्रीय वद्यालय -1 रुड़की 30 अगस्त 2018
17.	'स्वच्छता ही सेवा अ भयान'	बा लका छात्रावास,कस्तूरबा गांधी बा लका वद्यालय बाजूहेड़ी, जिला हरिद्वार 1 October, 2018
18.	14th Jatiyo Sanhati Utsav O Bharat Mela in association with Bangio Seva Samity,	12-16 December, 2018 at Sonarpur, West Bengal
19.	Mass Awareness Program on ' Water Qaulity issue of the Coastal regions and functions of Water Quality Lab Equipment' for ASD Women's College, Kakinada	5th Feb., 2019 at DRC, Kakinada
20.	Mass Awareness Program on ' Water Qaulity and Quantity issues and Water Quality Lab Equipment' for Ideal college of Arts and Sciences, Kakinada	28th Feb., 2019 at DRC, Kakinada

21.	Cleaning of Village Pond under Swachhta Pakhwada 2019	17 March 2019 at Shankar Puri Village, Roorkee
22.	Brain Storming Session (World Water Day) under Swachhta Pakhwada 2019	22 March, 2019 at NIH Roorkee
23.	Motivating school children for cleaning activities and plantation under Swachhta Pakhwada 2019	25 March, 2019 at St. Joseph School, Jadugar Road, Roorkee
24.	Drawing/ Poster competition for children and rally under Swachhta Pakhwada 2019	26 March, 2019 at NIH, Roorkee
25.	Workshop for women on cleanliness, sanitation and water conservation under Swachhta Pakhwada 2019	28 March, 2019 at Jal Vihar Colony, NIH, Roorkee
26.	Swachhata Pakhwada-2019	15 – 31 March, 2019 at WHRC, Jammu

APPENDIX 72.5.1

MINUTES OF THE 47th MEETING OF THE WORKING GROUP OF NIH

MINUTES OF THE
47TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING 23-24 OCTOBER 2018

The 47th meeting of the Working Group of NIH was held at NIH, Roorkee, during 23-24 October 2018 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 47.1: OPENING REMARKS BY THE CHAIRMAN

Dr. S K Jain, Director, NIH & Chairman, WG welcomed the Working Group members and the Scientists of the Institute. The Chairman informed the house about the expectation of the government that the research at NIH should lead to solution of practical problems.

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

S N	Member	Suggestion(s)
1	Dr. D R Sena	▪ Suggested use of ecological index ▪ Advised consideration of the effect of CO_2 while using carrying out SWAT modelling
2	Dr. D K Singh	▪ Suggested consideration of hydrological zoning while estimating groundwater recharge potential ▪ Also consider CO_2 values in RCP results
3	Dr. U K Sinha	▪ Include isotopic analysis in most of the studies
4	Dr. M J Nandan	▪ Advised study on limnology of urban lakes
5	Dr. S P Aggarwal	▪ Develop flood early warning system for Uttarakhand ▪ Work for urban floods ▪ Suggested developing methodology on the use of extreme events for design of structures
6	Dr. George Abe	▪ Advised internal discussion before presentation of inter-divisional projects/studies
7	Prof. Vimal Mishra	▪ Include list of publications during the last 3 years ▪ Publish papers in reputed journals ▪ Each project should be judged by its scientific outcome ▪ Consider working for operational hydrology forecasts (e.g. real time ET, SM) ▪ Develop internal data repository
8	Prof. K K Singh	▪ Develop calibration facility for hydromet equipment ▪ Organize training of lab staff and technicians
9	Prof. M L Kansal	▪ Show outlay of studies
10	Dr. Bhishm Kumar	▪ Create data repository, and link with NIH website
11	Dr. Sadhana Malhotra	▪ Carry out cost-benefit analysis for projects/studies ▪ Consider ecological viability of studies ▪ Models developed should become source of revenue ▪ Organize programs for development of soft skills

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. 47.2: CONFIRMATION OF THE MINUTES OF 46th MEETING OF THE WORKING GROUP

The 46th meeting of the Working group was held during 8-9 Feb., 2018. The minutes of the meeting were circulated to all the members and invitees vide letter No. RMOD/WG/NIH-10 dated 19 March 2018. No Comments were received. The members confirmed the Working Group minutes.

ITEM No. 47.3: 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 46th working group meeting.

ITEM Nos. 47.4: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR YEAR 2018-19

The Member-Secretary requested the respective Divisional Heads to present the progress of studies carried out during 2018-19. Accordingly, the progress of various studies and sponsored projects was presented by all Scientific Divisions during the two day deliberations of the Working Group. The Division wise minutes of each study/project presented during the meeting are given next.

ENVIRONMENTAL HYDROLOGY DIVISION

PROGRESS OF WORK PROGRAMME 2018-19

SN	Study	Recommendations/Comments
	Internal Studies (Continuing)	
1.	Development of Habitat Suitability Curves for the Aquatic Species of Western Himalayan Streams and Assessment of Environmental Flows **Study Group:** Pradeep Kumar and C. K. Jain Duration: **3 Years (04/16-03/19)**	No comments
	Sponsored Projects (Continuing)	
1.	Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin **Study Group:** C. K. Jain (PI), Manohar Arora, M. K. Sharma, P. Kumar, R. Singh and D. S. Malik (GKU) **Duration:** 5 Years (04/16-03/21)	No comments
2.	Ground Water Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District of Chhattisgarh State and Ameliorative Measures **Study Group:** NIH**:** M. K. Sharma (PI), C. K. Jain, Surjeet Singh, Pradeep Kumar **WRD, Raipur:** A. K. Shukla (PI), Ashok Verma, P. C. Das **CGWB, Raipur:** A. K. Patre **Duration:** 03 Years (09/17-08/20)	• Dr. Bhishm Kumar suggested to collect the samples from deep aquifers which are being used by the public for quality aspect. Dr. Sharma replied that samples from deep aquifer will be collected in nexr sampling. • Dr. Uday Kumar Sinha enquired how quality can be improved by modelling. Dr. Surjeet Singh supplemented that modelling will help in generating future scenarios and consider the impact of recharge.
3.	Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures **Study Team:** Rajesh Singh (PI), Pradeep	• Dr. Sharad Jain and Dr. Bhism Kumar suggested including the analysis of probable carcinogens in other routes of exposure that may lead to cancer.

	Kumar, M. K. Sharma, Sumant Kumar **Partner:** Water Resources Organization, Punjab **Sponsored by:** NHP-PDS **Duration:** 3 Years (09/17 – 08/20)	

APPROVED WORK PROGRAMME FOR THE YEAR 2018-19

SN	Study	Recommendations/Comments
	Internal Studies (Continuing)	
1.	Development of Habitat Suitability Curves for the Aquatic Species of Western Himalayan Streams and Assessment of Environmental Flows **Study Group:** Pradeep Kumar and C. K. Jain Duration: **3 Years (04/16-03/19)**	-
	Internal Studies (New)	
2.	Impact of Climate Change on Runoff and Sediment Yield for a Major Tributary of River Brahmaputra **Study Group:** Swapnali Barman (PI) and J. V. Tyagi **Collaborator**: Prof. R. K. Bhattacharya, IIT Guwahati **Duration**: 3 years (11/18 to 10/21)	• Instead of going for downscaling of GCM data, available downscaled data can be used for the study. • More time should be given to develop the SWAT model. • Thorough literature survey is to be made to understand the sediment characteristics of river Brahmaputra.
	Sponsored Projects (Continuing)	
1.	Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin **Study Group:** C. K. Jain (PI), Manohar Arora, M. K. Sharma, P. Kumar, R. Singh and D. S. Malik (GKU) **Duration:** 5 Years (04/16-03/21)	-
2.	Ground Water Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District of Chhattisgarh State and Ameliorative Measures **Study Group:** NIH**:** M. K. Sharma (PI), C. K. Jain, Surjeet Singh, Pradeep Kumar **WRD, Raipur:** A. K. Shukla (PI), Ashok Verma, P. C. Das **CGWB, Raipur:** A. K. Patre **Duration:** 03 Years (09/17-08/20)	-
3.	Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures **Study Team:** Rajesh Singh (PI), Pradeep Kumar, M. K. Sharma, Sumant Kumar **Partner:** Water Resources Organization, Punjab **Sponsored by:** NHP-PDS **Project Cost:** 65.6 Lakh **Duration:** 3 Years (09/17 – 08/20)	-

GROUND WATER HYDROLOGY DIVISION

Dr. N. C. Ghosh, Scientist 'G' & Head presented a brief overview, status of studies and activities carried out by the division since the 46th Working Group meeting held in February, 2018. He gave an account of sponsored and consultancy projects ongoing and completed, and also planned activities. Dr. Ghosh informed that one in-house R&D study and ten sponsored studies were approved in the work program for the year 2018-19. In addition, scientists in the division have responsibilities of implementation and management of DSS(P) developed under HP-II for different states and also in developing the groundwater module of the "Integrated Hydrologic Model" under an ongoing NHP study with IIT Kharagpur.

The number of research papers published in journals, lectures delivered in training courses and the number of M.Tech/Ph.D students guided/guiding during the period were also reported. Dr. Vimal Mishra from IIT Gandhinagar enquired about the reasons of limited number of publications during the period despite good works being done by the scientists. Dr. Ghosh informed that the papers published in journals (not presented/published in Symposia/Conferences) had only been indicated; papers under review had not been included in the list.

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

1. Project Ref. Code: NIH/GWD/NIH/15-19: **Peya Jal Suraksha - Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply**

Dr. N. C. Ghosh (PI) briefed about the study and progress made so far on the project. Currently four sites; Agra & Mathura in U. P. along Yamuna river, Berhara village in Arrah district in Bihar along the Ganga river, and Varaha River at Vishakapatnam are being pursued for developing RBF wells through respective state water supply department. Money for taking up the Phase-II of the Agra and Mathura site involving installation of submersible pumps, establishment of pump house and other facilities has been provided to U.P. Jal Nigam Agra unit and the works are likely to start. For other two sites, Arrah and Vishakapatnam, geophysical survey's have been completed and moneies for the Phase-I had been provided to the respective state govt. utility groups.

2. Project Ref. Code: NIH/GWD/NIH/16-20: **Ground water fluctuation and conductivity Monitoring in Punjab- New evidence of groundwater dynamics in Punjab from high frequency groundwater level and salinity measurements**

It was reported that water loggers were installed in the Saroya, Bhogpur and Sultanpur Lodhi in the month of May, 2018 considering the physiography, geomorphology and hydro-geological conditions of the area. Data are being monitored on a regular interval of time. The results for conductivity data showed that there were some irregular trends. e.g. in Saroya, the conductivity fluctuations were about 40 µS/cm while at Kapurthala the fluctuations were within 10 µS/cm.

3. Project Ref. Code: NIH/GWD/NMSHE/16-20: **Study of river - aquifer interactions and groundwater potential in the upper Ganga basin up to Dabrani**

Dr. Surjeet Singh (PI) presented the objectives, methodology, achievements and expected outcome of the study. He also described the geology and soils, status of installation of piezometers, water sampling & analysis being carried out, future plans and results of water quality and isotopic analysis. PI informed that many isotopic data points are not lying along the GMWL, for which Director NIH advised to test the samples again.

4. Project Ref. Code: NIH/GWD/NIH/16-19: **Grey Water to Blue Water – Natural Treatment Techniques for Transforming Wastewater into Sustainable Useable Water**

Dr. N. C. Ghosh (PI) informed that because of non-suitability of land provided by the Civil Administration along the Solani river in the Khanapur village for installation of the proposed scheme and due to the resistance from the local villagers, the development & persuasion of the field experimental works are under hold since May, 2017 and continuation of the project in such condition is under question. As such, no progress towards the activities of the project except procurement of ICP-OES for water quality analysis has been made.

5. Project Ref. Code: NIH/GWD/DST/18-20: **Future Secular Changes and Remediation of Groundwater Arsenic in the Ganga River Basin-FAR GANGA**

Dr. N. C. Ghosh (India Lead) presented the progress made so far on the project funded under the Indo-UK - DST NERC-EPSRC Newton Bhabha Fund. He informed that the project is of 4 x 4 consortium partner from each country and the Indian partners are NIH (Indian Lead); IIT Kharagpur, IIT Roorkee; and Mahavir Cancer Sansthan, Patna and that of UK partners are University of Manchester (UK Lead), British Geological Survey, Salford University; and Univ. of Birmingham.

While presented the objectives, and hypotheses to be tested in the project, Dr. Ghosh informed that two review meetings in India to decide responsibilities, common sampling protocol, sharing of data/information, and other aspects took place in Patna and Varanasi. Two rigorous sampling campaigns, Bijnor and Moradabad aiming to examine the possibility of establishing 'Natural Field Experimental' site in the upper Ganga plain had been carried out and most of the samples had been analyzed from the IIC-IIT Roorkee and CSSRI-Karnal. No positive results for establishing the field experimental site either at Bijnor or Moradabad area were obtained. The future targeted area for the field experimental site has planned for Ballia district in U.P.

6. Project Ref. Code: NIH/GWD/DST/18-20: **Impact of Rainwater Harvesting on Groundwater Quality in India with Specific reference to Fluoride and Micro-pollutants**

Dr. Anupma Sharma (India Lead PI) presented the study approved under the India-UK DST-NERC-EPSRC Water Quality Research Programme (Newton Bhabha fund). The research gaps, objectives of the study, and the work packages were presented. The study sites in which field investigations are being conducted were discussed. The details of the three-day Indo-UK consortium meeting held in Jaipur was also informed.

7. Project Ref. Code: NIH/GWD/PDS/18-21: **Ganges Aquifer Management in the context of Monsoon Runoff conservation for sustainable River Ecosystem Services- A Pilot study**

Dr. Surjeet Singh (PI) presented the background, statement of the problem, objectives, methodology and future plans of the study. In the previous 46th WG Meeting, Dr. M. L. Kansal, Professor, had IITR suggested a minor change in the name of PDS, which was replied by PI. No comments/suggestions were made.

8. Project Ref. Code: NIH/GWD/PDS/18-20: **Assessment of impacts of groundwater salinity on regional groundwater resources, current and future situation in Mewat, Haryana – possible remedy and resilience building measures**

Dr. Gopal Krishan (PI) presented the background, statement of the problem, objectives, methodology, progress and future plans of the study. Dr. D. R. Sena, Principal Scientist, IISWC, Dehradun advised to do the trend analysis of water level and cumulative rainfall departure Dr. Bhishm Kumar and Dr. U. K. Sinha advised to do the sampling for isotopes (stable and tritium) to monitor the saline zone ingression into fresh water zone.

9. Project Ref. Code: NIH/GWD/PDS/18-20: **Hydro-geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin**

Mr. Sumant Kumar (PI) presented the objectives, methodology, achievements and expected outcome of the study. A Working Group member suggested that Maxent or similar software may be used for spatial analysis of arsenic distribution.

10. Project Ref. Code: NIH/GWD/PDS/18-20: **Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin upto Delhi**

Dr. Anupma Sharma (PI) presented the new study taken up under the Centre of Excellence for Hydrologic Modeling in National Hydrology Project. She informed in brief about the background of the study and the project partners. The project entails large data processing, field investigations and modeling studies pertaining to surface water and groundwater flows, contaminant transport and water resources management. The progress made in respect of data collection and processing, field experiments and hydrologic modeling was presented. It was suggested by Working Group Members that based on the understanding gained about the field processes during the course of the project, improvisations may be attempted in the respective modules of hydrologic models.

11. Project Ref. Code: NIH/GWD/NIH/18-19: **Application for Conjunctive use management of SW & GW in Saryu Nahar Pariyojna, U.P. using "Strategic Basin Planning for Ganga River Basin"**

Ms. Suman Gurjar explained the methodology and different modules used in the integrated system. She also informed that the integrated system is still not fully updated and presently the final version is not working properly. There are issues in running and customizing the network schematization, and she is trying to get the solution with the consultant team.

It was informed by Ms. Gurjar that when the updated version of integrated system is received and found to work properly, this study will be taken up further.

The work program of the division for the year 2018-19, as discussed in the Working Group meeting, is given below.

WORK PROGRAM FOR THE YEAR 2018-19

S. No.	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/ NIH/15-18	Peya Jal Suraksha - Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply	N.C. Ghosh (Lead), C.P. Kumar, B. Chakraborty, Y.R.S. Rao, Anupma Sharma, Surjeet Singh, Sumant Kumar, Gopal Krishan, Suman Gurjar, Anju Choudhury, Sanjay Mittal, Ram Chandar	2-1/2 year (11/15 – 4/18) Extended by one year. **Status: In progress**.	Sponsored by MoWR, RD & GR under Plan Fund.
2. NIH/GWD/ BGS/16-20	Ground water fluctuation and conductivity Monitoring in Punjab- New evidence of groundwater dynamics in Punjab from high frequency groundwater level and salinity measurements	**From : NIH, Roorkee** Gopal Krishna, (PI) Surjeet Singh, C. P. Kumar, N.C Ghosh **From : BGS, UK** Dr. Dan Lapworth (PI) Prof. Alan MacDonald	03 Years (01/16-11/20) **Status: In progress**.	**Sponsored by** BGS, UK
3.NIH/GW D/NMSHE/ 16-20	Study of river - aquifer interactions and groundwater potential at selected sites in the upper Ganga basin up to Dabrani.	Surjeet Singh (PI), N.C. Ghosh, R. J. Thayyen, Sudhir Kumar, Manohar Arora, Gopal Krishan,	5 year (01/16–12/20) **Status: In progress.**	Sponsored by DST under NMSHE SP-8.
4. NIH/GWD/ NIH/16-19	Grey Water to Blue Water – Natural Treatment Techniques for Transforming Wastewater into Sustainable Useable Water	N.C. Ghosh (Lead), Anupma Sharma, Surjeet Singh, Sumant Kumar, Suman Gurjar, Anju Chaudhury, Sanjay Mittal, Ram Chandar, etc.	3 years (11/16-10/19) **Status: In hold. Partners:** IIT Bombay UJS, D. dun	Sponsored by NWM, MoWR, RD & GR

5.NIH/GWD/DST/18-20	Future Secular Changes and Remediation of Groundwater Arsenic in the Ganga River Basin-**FAR GANGA**	**NIH-Team:** N. C. Ghosh (India Lead) Surjeet Singh; Sumant Kumar; Gopal Krishan; Suman Gurjar **Other India partners:** IIT Roorkee; IIT Kharagpur; & Mahavir Cancer Sansthan, Patna. **UK- Partners:** Univ. of Manchester; BGS; Salford University; Univ. of Birmingham.	**3 years** (01/18–12/20) **Status: In progress.**	DST-Newton Bhabha-NERC-India-UK Water Quality Research Programme.
6.NIH/GWD/DST/18-20	Impact of Rainwater Harvesting on Groundwater Quality in India with Specific reference to Fluoride and Micro-pollutants.	**NIH-Team:** Anupma Sharma (Indian Lead); Sumant Kumar; Gopal Krishan; Suman Gurjar and M. K. Sharma **Other Indian partners:** IIT Ropar & IIT Jodhpur. **UK Partner:** Cranfield University School of Water, Energy and Environment; Cranfield University	**3 years** (01/18–12/20) **Status: In progress.**	DST-Newton Bhabha-NERC-India-UK Water Quality Research Programme.
7. NIH/GWHD/PDS/18-22	Ganges Aquifer Management in the context of Monsoon Runoff conservation for sustainable River Ecosystem Services- A Pilot study	Surjeet Singh, (PI), N.C Ghosh, Sudhir Kumar, C. P Kumar, Suman Gurjar, Gopal Krishan **Implementing Agency:** GW Deptt., Govt. of UP	04 Years (03/18-02/22) **Status:** **In progress.**	Sponsored by NHP under PDS
8. NIH/GWHD/PDS/18-20	Assessment of impacts of groundwater salinity on regional groundwater resources, current and future situation in Mewat, Haryana – possible remedy and resilience building measures	NIH, Roorkee, India Gopal Krishan (PI), N. C. Ghosh, Surjeet Singh, C.P. Kumar **IIT-Roorkee** M.L. Kansal, Brijesh Yadav (PI) **Sehgal Foundation, Gurgaon** Lalit Mohan Sharma	03 years (01/18-12/20) **Status: In progress.**	Sponsored by NHP under PDS
9. NIH/GWHD/PDS/18-20	Hydro-geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin	Sumant Kumar (PI), N.C. Ghosh, Sudhir Kumar, Rajesh Singh, Gopal Krishan, Anju Chaudhary, Ram Chander Partner Organization **MWRD, Bihar** Collaborator **Brijesh Yadav, IIT Roorkee** **N.S Maurya, NIT Patna**	03 years 01/18-12/20 **Status: In progress.**	Sponsored by NHP under PDS
10.NIH/GWD/PDS/18-20	Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin upto Delhi.	**NIH Team:** Anupma Sharma (PI) N.C Ghosh, Sanjay K. Jain, Archana Sarkar, M.K. Sharma, L.N. Thakural, Sumant Kumar, Suman Gurjar **Partner Organization:** Sanjeev Bansal (C.E, IWRD	04 years 04/18-03/22 **Status: In progress.**	Special Project under “Centre of Excellence”

		Haryana), Amod Kumar (Tech. Coord., GWD U.P), S.E. YBO, CWC New Delhi		
11. NIH/GWD/ NIH/18-19	Application for Conjunctive use management of SW & GW in Saryu Nahar Pariyojna, U.P. using "Strategic basin Planning model for Ganga River Basin"	Suman Gurjar (PI), Jyoti Patil (Co-PI), N.C. Ghosh, Anupma Sharma, Sumant Kumar, Surjeet Singh	1 Year (04/18–03/19) **Status: In progress**	Internal Funding.

HYDROLOGICAL INVESTIGATIONS DIVISION

Dr Sudhir Kumar, Scientist-G and Head of the H. I. Division presented the brief details of various studies being carried out under the H. I. Division along with details about the number of research papers published/accepted for publication/communicated and analytical work carried out at the Nuclear Hydrology Laboratory. He also informed about the technology transfer activities organized/proposed by the Division.

Table 1: Status of studies of HI Division

Type of study/Project	Continuing in Studies	New studies proposed	Total
Internal Studies	0	0	0
Sponsored Projects	6	1	7
Consultancy Projects	7	1	8
Total	13	2	15

The progress of studies was presented by the respective P.I. of the study. The actions suggested by the working group for various studies are as follows:

SPONSORED PROJECTS:

SN	Project	Duration	Funding	Status	Action(s) Suggested
1.	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	5 Years (04/16-03/21)	NMSHE Project	Continuing Study	No specific action suggested
2.	Rejuvenation of Springs and Spring-fed Streams in Mid-Himalayan Basin using Spring Sanctuary concept	3 Years (06/16 - 05/19)	Project with GBPIHE	Continuing Study	No specific action suggested
3.	Dating very old ground waters of deeper aquifers in Ganga Plains, India	3 Years (06/16 - 05/19)	IAEA	Continuing Study	No specific action suggested

4.	Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin	3 ½ year (1/18 – 6/21)	PDS under NHP	Continuing Study	No specific action suggested
6.	Development of a comprehensive plan for conservation and sustainable management of Bhimtal and Naukuchiatal lakes, Uttarakhand	3 Years 18/1)– (20/12	PDS under NHP	Continuing Study	No specific action suggested

WORK PROGRAMME FOR THE YEAR 2018-2019

SN.	Project Title	Study Team	Duration	Remarks
INTERNAL STUDIES:				
SPONSORED PROJECTS:				
1.	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	SuhasKhobragade (PI) Sudhir Kumar Rajesh Singh M. Arora R. J. Thayyen S.K. Verma	5 Years (04/16-03/21)	NMSHE Project
2.	Rejuvenation of Springs and Spring-fed Streams in Mid-Himalayan Basin using Spring Sanctuary concept	Sudhir Kumar (PI) S.K. Verma	3 Years (06/16 - 05/19)	Project with GBPIHE
3.	Dating very old ground waters of deeper aquifers in Ganga Plains, India	M. Someshwar Rao (PI) Sudhir Kumar C.K. Jain S.K. Verma	3 Years (06/16 - 05/19)	IAEA under CRP
4.	Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin	Sudhir Kumar (PI) C.K. Jain M. Someshwar Rao S.K. Verma	3 ½ year (1/18 – 6/21)	PDS under NHP
5.	Integrated Study on groundwater dynamics in the coastal aquifers of West Bengal for sustainable groundwater management	M. Someshwar (PI), Sudhir Kumar S.K. Verma A. R. Senthil Kumar V. S.Jeyakanthan	3 ½year 18/1)– (21/6	PDS under NHP
6.	Development of a comprehensive plan for conservation and sustainable management of Bhimtal and Naukuchiatal lakes, Uttarakhand	Suhas Khobragade Sudhir Kumar	3 Years 18/1)– (20/12	PDS under NHP

7	Climate resilient conservation & data management of spring water sources by strengthening monitoring mechanisms in drought prone areas of Sikkim	Sudhir Kumar Suhas Khobragade	6 months (11/18 – 04/19)	UNDP-India (**New Project**)

SURFACE WATER HYDROLOGY DIVISION

WORK PROGRAM FOR THE YEAR 2018-19

ONGOING STUDIES(Sponsored)			
1.NIH/SWHD/NIH/16-21	Hydrological modeling in Alaknanda basin and assessment of climate change impact	A.K. Lohani Sanjay K. Jain Archana Sarkar V.S. Jeyakanthan L.N. Thakural	**Sponsored by NMSHE** 5 years (April 2016 to Mar. 2021)
2.NIH/SWHD/NIH/17-20	Water efficient irrigation by using SCADA system for medium irrigation project (MIP) Shahnehar	R.P. Panday J.P. Patra Rajesh Singh N.K. Bhatnagar	**PDS under NHP** 3 years (Dec 2017-Dec 2020)
3.NIH/SWHD/NIH/17-19	Impact Assessment of Climate Change on Water Resources and Agriculture in Banas basin in Western India using Climate change Indicators (CII's). Approval for signing the sub-contract with SMHI and transfer of funds to NIH has not been received. Therefore, NIH continues in the consortium as "In Kind Partner". The objectives of CII development and script writing will be taken up by the core team at SMHI with help from NIH.	Archana Sarkar Surjeet Singh T. Thomas	1.5 years (Sep. 2017 to Feb. 2019)
4.NIH/SWHD/NIH/14-18	Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India	Ashwini Ranade	**Sponsored by SERB-DST** 4 years (Oct. 2014 to Nov. 2018)
ONGOING STUDIES (Internal)			
5.NIH/SWHD/NIH/17-21	Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin Subzone 3(f)	Sanjay Kumar Rakesh Kumar J. P Patra Pankaj Mani	4 years (April 2017 to March 2021)
6.NIH/SWHD/NIH/15-19	Study of Hydrological Changes in selected watersheds in view of climate change in India	L.N. Thakural D.S. Rathore Surjeet Singh Sanjay Kumar Jain Sharad Kumar Jain	4 years (April 2015 to March 2019
7.NIH/SWHD/NIH/17-20	Development of regional methods for design flood estimation in Uttarakhand	J.P. Patra Rakesh Kumar Pankaj Mani Sanjay Kumar	3 years (April 2017 to March 2020)

8.NIH/SWHD/NIH/18-21	Evaluation of seasonal extreme rain events across river basins of India in 3D global temperature change scenario	Ashwini Ranade Archana Sarkar	3 years (April 2018 to March 2021)
NEW STUDIES			
9.NIH/SWHD/NIH/18-20	Assessment of climate change impact on water availability and agriculture in part of Banas basin	Archana Sarkar Surjeet Singh Suman Gurjar Sunil Gurrapu	2 years (Nov 2018 to October 2020)
10.NIH/SWHD/NIH/18-21	Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent	Sunil Gurrapu Ashwini Ranade J.P. Patra	3 years (Nov 2018 to March 2021)
11.NIH/SWHD/NIH/18-20	Evaluation of Water Quality of Government Schools in Roorkee Block, District Haridwar	N. K. Bhatnagar M. K. Sharma L. N. Thakural Reena Rathore	2 years (Oct 2018 to Sep. 2020)

S. No.	Title of Project/Study, Study Group, Start/ Completion Dates	Status and Recommendations/Suggestions
SPONSORED STUDIES		
1.	Hydrological modeling in Alaknanda basin and assessment of climate change impact (Ongoing). Study Group: A.K. Lohani Sanjay K. Jain Archana Sarkar V.S. Jeyakanthan L.N. Thakural **DOS:** Jan. 2016 **DOC:** Dec. 2020	Dr. Sanjay Kumar Jain, Co-PI of the project presented the progress of the study. He mentioned that various maps such as landuse map, DEM, river network, snow cover area maps have been prepared. Furthermore, temporal meteorological data have been collected for the study basin. VIC model has been setup for the study basin. Recently flow data of various gauging sites have been received from CWC and the calibration and fine-tuning of the model with the available data is in progress. He mentioned that the progress of the study is as per the schedule.
2.	Water efficient irrigation by using SCADA system for medium irrigation project (MIP) Shahnehar (Ongoing) PDS under NHP. Study Group: R.P. Panday J. P. Patra Rajesh Singh N.K. Bhatnagar **DOS:** Dec. 2017 **DOC:** Dec. 2020	Dr. R.P. Pandey, PI of the project reported that this study has been taken up in collaboration with Department of Irrigation & Public Health Engg. (I&PHE), Hydrology C&M Division, Himachal Pradesh. NIH team has conducted field visit of the Shahnehar and identified experimental sides and collected data/information in respect of this study. The objectives of this study are to assess water availability at headworks and devise a suitable approach to improve irrigation water use efficiency in Shah Nehar Project (SNP) and automation of the irrigation water supply system based on real time crop water demands. The proposed methodology and the work component include develop a system of water supply database of quantum of water used to each beneficiary so the charges can be levied accordingly; devising a possible system

		of change in cropping pattern owing to real time monitoring of available water at various reaches of the canal; evaluation of land and water management intervention to minimize water losses throughout the canal and distribution system, water courses and in the field application to enhance the water use efficiency; devising a mechanism for equitable distribution of water to the farmers in each crop period from head to tail reaches. Comparison of Water Efficient Irrigation approach with the conventional system and to identify and evaluation of intervention to minimize water losses throughout the canal and distribution system, water courses and in the field application to enhance the water use efficiency. The deliverables of the study will be estimates of water availability at headwork's and irrigation water requirements for various crops a different growth stages & time period; quantification of irrigation water loss in different conveyance & distribution systems, field channels, and irrigation application method; identification of components of irrigation system needing intervention to enhance water use efficiency etc. Further the progress was reported. The working group members suggested to take care of between theft of water from canal as it is common problem in command areas in the country. Also, they asked about the present conveyance efficiency. Dr Pandey informed that the canals in the entire command are lined and the lining is in very good and sustainable condition with high conveyance efficiency.
3.	Impact assessment of climate change on water resources and agriculture in Banas basin in Western India using climate change Indicators (CII's) (Ongoing). Study Group: Archana Sarkar Surjeet Singh T. Thomas **DOS:** Sep. 2017 **DOC:** Feb. 2019	Approval for signing the sub-contract with SMHI and transfer of funds to NIH has not been received. Therefore, NIH continues in the consortium as "In Kind Partner". The objectives of CII development and script writing will be taken up by the core team at SMHI with help from NIH
4.	Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India (Ongoing). Study Group: Ashwini Ranade **DOS:** Oct. 2014 **DOC:** May 2018	Dr. Ashwini Ranade, PI of the project presented the objectives and current status of the project. She also presented some important results of the study that have been obtained in last six months. The working group members appreciated the work on determination of onset and withdrawal of monsoon circulation and monsoon rains over 19 subdivisions of India.
INTERNAL STUDIES		
5.	Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin (3f) (Ongoing). Study Group:	Dr. Sanjay Kumar presented the background, objectives and methodology. He stated that the study specifically focuses on developing design flood estimation methods for partially gauged or un-gauged regions based on the concept of regionalization using L moments approach. The study would also develop regional relationships between parameters of the

	Sanjay Kumar Rakesh Kumar J. P. Patra Pankaj Mani **DOS:** April 2017 **DOC:** March 2021	Nash and Clark IUH models and physiographic characteristics of the basin. He mentioned that at site frequency analysis based on L-moments approach for eleven sites has been completed. He stated that data preparation and analysis for other objectives is in progress. Prof. Vimal Mishra mentioned about the availability of gridded rainfall satellite data and inquired why there is a need to specify these basins as ungauged. It was replied that when river flow data are not available for various locations the catchments are considered as ungauged catchments. It was also stated that flood hydrographs for some of the gauged catchments of the study areas may be estimated by calibrating and validating catchment models such as NAM. Using the parameters of the model and rainfall data, flood hydrographs of nearby ungauged catchments would be estimated.
6.	Study of hydrological changes in selected watersheds in view of climate change in India (Ongoing). Study Group: L.N. Thakural S. Rathore Surjeet Singh Sanjay Kumar Jain Shard Kumar Jain **DOS:** April 2015 **DOC:** March 2019	Dr. L.N. Thakural, PI presented the objectives, methodology and the status of the study. The GIS database created to meet out the objectives of the study using Digital Elevation Model (DEM) and satellite imagery for flow accumulation, stream network, watershed boundary, land use / land cover thematic maps in addition to soil map for the four watersheds have been prepared. Spatio-temporal analysis of hydro-meteorological data using parametric and non-parametric approaches for the Ramganga, Bina and Chaliyar river basins was also presented. The outcome/ results of hydrological models (NAM and SWAT) calibrated and validated for the river basins i.e. Ramganga, Bina, Chaliyar and Dhadhar river basins were presented. For studying the impact of climate change, gridded rainfall and temperature data, historical NCEP/NCAR reanalysis data (observed predictors) and GCM Predictor grid boxes for the four river basins processed to generate Representative Concentrations Pathways (RCP) namely RCP 2.6 RCP 4.5, RCP 6 and RCP 8.5 using statistical downscaling model (SDSM) were presented. Dr. Sena, ICAR-IISWC, Dehradun suggested to use the range of carbon concentration values while defining the land use/land cover input in SWAT model along with the RCP scenarios.
7.	Development of regional methods for design flood estimation in Uttarakhand (Ongoing). **Study Group:** J.P.Patra Rakesh Kumar Pankaj Mani Sanjay Kumar DOS: April 2017 DOC: March 2020	Mr. Jagadish Prasad Patra presented the the objectives and the progress made in carring out the study. He explained the flood frequency analysis carried out using L-moments approach. Further the progress made in the non-stationary extreme value analysis was presented. The uses of estimated design floods for designing bridges, embankments and flood plain mapping were also presented. It was informed that aspect of climate change will also be considered in rainfall frequency analysis. It was informed that daily rainfall data of 33 raingauge stations collected from IMD along with gridded rainfall data from 1901 to 2013 are being used the study. It was also informed that request has been made to CWC for providing short interval rainfall and discharge data which will be used for developing regional Clark and Nash IUH models along with GIUH.
8.	Evaluation of seasonal extreme rain	Dr. Ashwini Ranade, PI presented the objectives, work plan

	events across river basins of India in 3D global temperature change scenario (Ongoing). Study Group: Ashwini Ranade Archana Sarkar **DOS:** April 2018 **DOC:** March 2021	and current status of the study. She presented a few important results from first objective. Working Group noted the work on updation of eleven major and nine independent minor river basin rainfall series and the trend analysis results to understand recent year changes in rainfall pattern.
NEW STUDIES (Internal)		
9.	Assessment of Climate Change Impact on Water Availability and Agriculture in part of Banas basin. Study Group: Archana Sarkar Surjeet Singh Suman Gurjar Sunil Gurrapu **DOS:** Dec. 2018 **DOC:** Dec. 2020	Dr Archana Sarkar, PI presented the background and objectives of the study. The Banas river basin upto Bisalpur dam and the irrigation command located in the State of Rajasthan in western India has been selected as the study area. Trend analysis of the historical & future patterns of rainfall and temperature time series in the study area will be carried out using modified Mann-Kendall's technique and Sen's Slope method. The future data time series will be taken from the GCM downscaled data of the Copernicus website which consists of data of 19 GCMs under two RCPs (RCP4.5 & RCP 8.5). Rainfall-runoff modelling in the catchment of Bisalpur dam will be carried out using SCS curve number method or MIKE NAM model depending on the availability of discharge data. After the calibration of the rainfall-runoff method, estimation of inflow and water availability in the form of dependable flows in Bisalpur reservoir will be carried out. The assessment of crop water requirements for the various crops grown in the selected commands/basin shall be carried out based on the FAO CROPWAT software based on the crop coefficients during the various crop growth stages and effective rainfall. Using the GCM downscaled data of precipitation and temperature, future water availability as well as future crop water requirement will be assessed. Based on this analysis, the gaps between the demand and supply can be ascertained so as to decide the quantum of additional water required to satisfy the unmet demands. Working group found the study to be a useful input for the PMKSY scheme of Government of India and suggested to prepare a policy paper at the end of the study.
10.	Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent. Study Group: Sunil Gurrapu Ashwini Ranade J P Patra **DOS:** Dec. 2018 **DOC:** Dec. 2021	Mr. Sunil Gurrapu, PI of the study presented the hypothesis of the proposed study, its objectives and tentative methodology. The primary objective of this study is to evaluate the influence of low-frequency atmosphere-ocean oscillations on the annual floods or annual peak flows in several watersheds of the Indian subcontinent. Since, it has been established that the Indian monsoon is significantly influenced by such teleconnections, e.g. Pacific Decadal Oscillation (PDO), El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) etc., the objective of this study is based on the hypothesis that the streamflow, i.e. the response of a watershed to the precipitation received, is also influenced by these teleconnections. Major data requirements for this study include daily streamflow and reservoir operation or rule curves. Suggestions and feedback from the committee was

		requested and the following suggestions were made. Dr. Vimal Mishra, IIT Gandhinagar appreciated the idea and made few suggestions to improvise the project and address some concerns regarding the data requirements. The first suggestion was related to the length of the available streamflow datasets. Since the streamflow data is available for a maximum of 30 years only, teleconnections with lower periodicity should be considered. He cautioned that although Indian monsoon is significantly correlated to low-frequency atmosphere-ocean oscillations, it may not be true in the case of annual floods since the streamflow is not very well correlated with the rainfall. However, he advised to do a feasibility study before making conclusions. Director, NIH raised a concern over the availability or reliability of the data related to the reservoir operations or rule curves. He indicated that the naturalization of regulated rivers may seem impossible with irregularities in the actual reservoir operations. Dr. Vimal Mishra suggested that the study should be first carried out for an unregulated river stretch (preferably upstream) or for a stretch with minimal regulation.
11.	Evaluation of Water Quality of Government Schools in Roorkee Block, District Haridwar. Study Group: N. K. Bhatnagar M. K. Sharma L. N. Thakural Reena Rathore **DOS:** Dec. 2018 **DOC:** Dec. 2020	The study was presented by Mr. N K Bhatnagar and undermentioned points were raised: Dr Sinha from BARC queried whether the study was a demand of Education Department? Have they contacted NIH or an initiative of NIH. It was informed that this problem was raised by Deputy Education Officer of Roorkee Block and accordingly the study has been taken up. Dr Sinha asked whether the amelioration will be done by NIH. It was informed that this may be done by school authorities. Dr K K Singh suggested that bacteriological testing also should be done. Dr M K Sharma replied in affirmation and added if any bacteria are found, simply boiling the water is the treatment.

WATER RESOURCES SYSTEMS DIVISION

SUGGESTION/ COMMENTS RECEIVED FROM MEMBERS

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

PI: Dr. M. K. Goel, Scientist "G"

1. ***Study title: NIH_Basin – A WINDOWS based model for water resources assessment in a river basin (Ongoing)***

Dr. M. K. Goel (MKG) presented the study. After giving a brief background and methodology of the model for the new members, the details of analytical options that have been added were presented. Subsequently, a run of the model was demonstrated through some forms specifying crops and hydraulic structure attributes and the utility of WINDOWS interface was shown. MKG informed that though it is envisaged to address the sedimentation and water quality issues in future, no more modifications are planned for the time being and study report along with the model is in progress for submission.

Dr. S. P. Agarwal appreciated for the efforts of NIH in this direction and enquired about the availability of the model. MKG clarified that it is planned to put the system on NIH web site for its wider applicability and use.

2. ***Study title: National Mission for Sustaining the Himalayan Ecosystem (NMSHE) (Ongoing)***

For the information of new members, MKG made a general presentation of the NMSHE project. Subsequently, presentation for seven sub-projects of NMSHE (in which Scientists of WRS Division are involved) were made.

Sub-project – 1: Development of a project website and hydrological database in Upper Ganga Basin (PI-Dr. M. K. Goel, Sc-G)
With regard to SP-1, Dr. A. K. Saraf enquired about the use of digitization of contours and preparation of DEM. MKG informed that though DEMs have been downloaded from various sources (SRTM, ASTER, CARTOSAT, ALOS), it is generally recommended to use the DTM. Further, contour-generated DEMs can be used to define the cross-sections for the GLOF-modeling studies. It is planned to compare various DEMs with the contour-generated DEM and analyze their differences. Finally, the drainage network derived from various DEMs would be compared for its accuracy and sub-basin boundaries of different tributaries and project locations would be delineated with accuracy.
Dr. Bhishm Kumar enquired about the display of database on the website being used in the project. It was informed that data of other organizations (IMD, CWC etc.) as such cannot be displayed. However, it is planned to put the abstract of data and the data availability on the website for use by researchers. It was conveyed that flow data of the study area is secret and undertaking to that effect is being taken from all users. BK opined that lots of isotopic data has been generated for the study area and all such data can be shared on website for use by various researchers.
The following sub-projects were briefly presented by the respective PIs.

Sub-project – 2: Real-time snow cover information system for Upper Ganga basin (PI-Mr. D. S. Rathore, Sc-F)
The progress of the project by briefly presented by Mr D. S. Rathore. No specific comments were received from members.

Sub-project – 3: Glacial Lakes & Glacial Lake Outburst Flood (GLOF) in Western Himalayan Region (PI-Dr. Sanjay K. Jain, Sc-G)
No specific comments were received from members.

Sub-project – 6: Hydrological modelling in Alaknanda basin and assessment of climate change impact (PI-Dr. A. K. Lohani, Sc-G and Co-PI-Dr. Sanjay K. Jain)
No specific comments were received from members.

Sub-project – 4: Assessment of downstream impact of Gangotri glacier system at Dabrani and future runoff variations under climate change scenarios (PI-Dr. Renoj J. Thayyen, Sc-D)
No specific comments were received from members.

Sub-project – 5: Observation and modelling of various hydrological processes in a small watershed in Upper Ganga basin (PI-Dr. Sharad K. Jain)
No specific comments were received from members.

Sub-project – 11: Water Census and Hotspot analysis in selected villages in Upper Ganga basin (PI-Dr. P. K. Mishra, Sc-C)
Results of the recent survey of 130 villages spread over four districts viz. Uttarkashi, Chamoli, Tehri Garhwal, and Pauri Garhwal were presented by Dr. P. K. Mishra (PKM). Dr. A. K. Saraf suggested to compare the findings from the survey with the available reports/ literature.

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

1. ***Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh (Ongoing)***

RJT presented the background of the project and summarized how ground ice melt and permafrost processes to be found important for the catchment.
No specific suggestions received for this project.

PI: Mr. D. S. Rathore, Scientist "F"

1. ***Design and development of DSS (H) platform for Neeranchal National Watershed Project (Ongoing)***

The progress of the project was presented by Mr D.S. Rathore. The DSS- H is being developed under Neeranchal National Watershed Project for nine state level agencies under World Bank funded project of Department of Land Resources (DoLR), Government of India. The objective of the study is to develop a web-based Decision Support System platform for deriving hydrological information required in preparation of DPRs for watershed development. DSS- H has presently five modules, namely data visualization, planning, sites and structures, impact assessment and DPR inputs. Development of tools and user interface is in progress. Database are being stored on PostgreSQL. OSGeo Geoserver is being utilized for publishing spatial data. Various tools e.g. potential evapotranspiration (Penman Monteith method), water quality index, groundwater recharge (rainfall infiltration method), surface runoff (SCS curve number technique), design discharge (empirical method), soil erosion (RUSLE), site suitability for structures, livelihood vulnerability index etc. are developed and other tools e.g. irrigation water requirement etc. are under development. Dr Vimal Mishra inquired regarding agency for which the system being developed and location for deployment of DSS. Mr Rathore replied that the DSS- H is being developed for state level agencies working for IWMP. Presently the system is located at NIH and will be handed over to state level nodal agencies (SLNA) and DoLR in due course.

2. ***Investigating water stress using hydro-meteorological and remote sensing data (Ongoing study under NHP-PDS)***

The project was briefly introduced by Dr Sanjay Kumar Jain. The project is taken up for Rajasthan state. Due to changes in the study area, the project was delayed and same was also communicated by the PI to the NHP Secretariat. It is expected that some progress will be achieved by the time of the forthcoming working group meeting.

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

1. Hydrological Processes and Characterization of Lesser Himalayan Catchments (Ongoing)

The progress of the study was presented by MKN. It was informed that almost all proposed instrumentation like 03 No. of AWSs; 10 no. of SRGs, two gauging sites, one AWLR; Eddy covariance tower, one COSMOS sensor; two Pan Evaporimeter etc. have been installed in the experimental catchment and data is being received at NIH, Roorkee. Soil monitoring station has also been established at project site. Some of the preliminary data analysis of rainfall, air temperature, humidity, wind speed and direction, solar radiation and various soil parameters were also shown and discussed during the presentation.
No specific comments were received from the members.

PI: Smt. Deepa Chalisgaonkar , Scientist "F"

1. ***Development of window based software for hydrological data processing and Unit Hydrograph Analysis (Ongoing)***

In the absence of Smt. Deepa Chalisgaonkar, Dr. Sanjay K. Jain informed about the progress of the study. In this study window based conversion of the existing software is progressing well.

PI: Dr. M. Arora (MA), Scientist "D"

1. Modeling of Gangotri Glacier melt runoff and simulation of stream flow variation under different climate scenarios (Ongoing study)

MA presented the progress of the study. The results for the study period 2014-2017 were presented before the experts.
No specific comments were received from the members.

PI: Dr. P. K. Singh (PKS), Scientist "D"

1. Developments of Water Accounts for Subarnarekha Basin Using Water Accounting Plus (WA+) Framework (New study)

PKS proposed the new study on Developments of water account for Subarnarekha basin using WA+ Framework. He briefly discussed the importance and relevance of global data used in WA+ as input. He also presented the different components under WA+ including the approach and methodology.
No specific comments were received from the members.

PI: Dr. Vishal Kumar (VK), Scientist "C"

1. Real time flood modelling using HEC-RTS modelling framework (New study)

VK proposed the new study on Real time flood modelling using HEC-RTS framework in Periyar river basin. He briefly presented the different components under HEC-RTS. He discussed about the recent Kerala flood events during the presentation.
No specific comments were received from the members.

WORK PROGRAMME FOR THE YEAR 2018-2019

SN	Title	Study Team	Duration	Funding (Rs. in Lakhs)
Completed Sponsored/ Internal Studies				
1.	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Sharad K. Jain Deepa Chalisgaonkar P. K. Mishra	3 years (04/13-12/17) Up to 06/2018	
Ongoing Internal Studies				
1.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S. P. Rai Sanjay K. Jain Sudhir Kumar	3 years (04/14-03/18) Up to 09/2018	
2.	Hydrological process and characterization of Lesser Himalayan Catchments	M. K. Nema Sharad K. Jain Sanjay K. Jain Renoj J.Thayyen P. K. Mishra P. K. Agarwal	5 years (12/14-12/19)	
3	Development of window based software for hydrological data processing and Unit Hydrograph Analysis	D. Chalisgaonkar A. K. Lohani M. K. Goel	1 year (04/18-03/19)	
Ongoing Sponsored Studies				
1.	Mass and Energy balance of Phuche and Khardung glaciers, Ladakh range	R.J. Thayyen Farooq Azam P.G. Jose A.P. Dimri	3 years (03/16-02/19)	SERB (65.14)
2.	Development of a project website and hydrological database in Upper Ganga Basin **(Sub-project – 1)**	M. K. Goel M. Arora A. K. Lohani D. S. Rathore D. Chalisgaonkar A. R. S. Kumar Surjeet Singh P. Mani A. Sarkar M. K. Nema P. K. Mishra	5 years (01/16-12/20)	DST (52.15)
3.	Real-time snow cover information system for Upper Ganga basin **(Sub-project – 2)**	D. S. Rathore D. Chalisgaonkar V. S. Jeyakanthan L. N. Thakural	5 years (01/16-12/20)	DST (48.83)
4.	Glacial Lakes & Glacial Lake Outburst Flood (GLOF) in Western Himalayan Region **(Sub-project – 3)**	Sanjay K. Jain A. K. Lohani Sudhir Kumar P. Thakur (IIRS)	5 years (01/16-12/20)	DST (36.79)
5.	Assessment of downstream impact of Gangotri glacier system at Dabrani and future runoff variations under climate change scenarios **(Sub-project – 4)**	Renoj J.Thayyen Sanjay K. Jain Sharad K. Jain S. P. Rai P. K. Mishra M. Arora	5 years (01/16-12/20)	DST 51.43 (NIH) + 28.29 (JNU)

		AP Dimri (JNU)		
6.	Observation and modelling of various hydrological processes in a small watershed in Upper Ganga basin **(Sub-project – 5)**	Sharad K. Jain Renoj J.Thayyen Sanjay K. Jain S. P. Rai Surjeet Sing M. K. Nema P. K. Mishra P. K. Agarwal AP Dimri (JNU)	5 years (01/16-12/20)	DST (54.07)
7.	Water Census and Hotspot analysis in selected villages in Upper Ganga basin **(Sub-project – 11)**	P. K. Mishra M. K. Nema R. J. Thayyen P. K. Sachan	5 years (01/16-12/20)	DST (90.99)
8.	Dynamics of Himalayan Ecosystem and its impact under changing climate scenario-Western Himalaya	Renoj J.Thayyen P. K. Mishra	3 years (03/17-03/19)	NMHS-MoEF (58.76 lakh)
9.	Measurements and Modeling of Evapotranspiration and other Hydrological Processes in Lesser Himalayas	M K Nema Renoj Thayyen Sharad K. Jain Sanjay K. Jain P. K. Mishra AP Dimri (JNU)	3 years (2016-19)	MOES (Rs. 98 Lakh)
10.	Sustaining Himalayan Water Resources in a Changing Climate (SusHi-Wat)	Sanjay K. Jain (PI) Sharad K. Jain CSP Ojha (PI, IITR)	3 years (2016-2019)	MOES-NERC, Newton-Bhabha project (11.59 Lakh)
11.	Design and development of generic Decision Support System-Hydrology platform for Neeranchal Project	D. S. Rathore Deepa Chalisgaonkar Jyoti Patil	1 year (04/17-03/19)	DoLR (NNWP)
12.	Investigating Water Stress using Hydro-meteorological and Remote Sensing data	D. S. Rathore L. N. Thakural Sanjay Kumar B. Venkatesh M. K. Jose T. Chandramohan	3 years 2017-2020	PDS under NHP
13.	Seasonal Characterization of Gangotri Glacier melt runoff and simulation of streamflow variation under different climate scenarios	M. Arora Sanjay K. Jain	3 years 2018-2021	NIH/ DST
New Internal/ Sponsored Studies				
1.	Developments of Water Accounts for Subarnarekha Basin Using Water Accounting Plus (WA+) Framework	P. K. Singh P. K. Mishra M. K. Goel Suman Gurjar	2 years 2018-2020	
2.	Real time flood modelling using HEC-RTS modelling framework	Vishal Kumar A. K. Lohani Sanjay K. Jain	2 years 2018-2020	

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)

WORK PROGRAMME FOR 2018-2019

SN	Title of Project/Study, Study Team	Status and Recommendations/Suggestions
1.	**Study on effect of climate change on sediment yield to Pong reservoir.** **Team:** A. R. Senthil kumar, J. V. Tyagi, S. D. Khobragade and Manohar Arora DOS: Apr 2015, DOC: September 2018	The objectives, brief methodology and present status of the study were presented by Dr A. R. Senthil Kumar (PI). The PI mentioned that the discharge and sediment yield at Nadaun Brdige (Pong reservoir) was simulated using SWAT using the data from 1993 to1996 for calibration and 1999 to 2002 for validation. The downscaling of rainfall for the scenarios RCP2.6, 4.5 and 8.5 were carried using SDSM from CanESM2. The downscaling of the data was done by the IMD gridded data from 1961 to 1995 for calibration and 1996 to 2005 for validation. Prof Vimal Mishra suggested to consider more GCM models to address the uncertainty in the downscaled data. Dr. D. K. Singh suggested to use APHRODITE rainfall data in addition to the data of IMD and ERA Interim. He aslo suggested to use SWAT CUP for the calibration of SWAT paramters to get the realistic values related to catchment and meteorological properties.
2.	**Bathymetric survey and water quality monitoring of selected ponds in Bundelkhand region for development of water management plan.** **Team:** Digambar Singh**,** Omkar Singh, Subhash Kichlu, Rajesh Kumar Nema, Hukum Singh and N R Allaka DOS: Apr 2018, DOC: March 2020	Shri Digambar Singh (PI) presented the objectives, methodology and progress related to the study. Dr. A K Saraf advised to include the ponds of Lalitpur district for the survey.
3.	**Conservation of ponds in Ibrahimpur-Masahi Village and performance evaluation of natural treatment system** **Team:** Omkar Singh, V C Goyal, Rajesh Singh, Digambar Singh, Subhash Kichlu, Rajesh Agarwal, Rakesh Goyal & N R Allaka **Partner Organization:** Centre for Ecology & Hydrology, Edinburgh, United Kingdom. DOS: Apr 2018, DOC: March 2020	The objectives, methodology and progress was presented by Sh. Omkar Singh (PI). The PI infomed that the necessary data collection including data on GHG emissions (viz. methane) from the pond with CW-NTS at Ibrahimpur Masahi and another control pond at Masahi Kala has been initiated in technical collaboration with CEH-UK team. There were no specific comments from working group members.
4.	**Vulnerability assessment of identified watersheds in Neeranchal Project States** **Team:** Dr Jyoti P Patil and nodal scientists from Regional centres (Bhopal, Patna, Kakinada, Belgaum) DOS: July 2017, DOC: June 2019 (**NNWP**)	The study was presented by Dr Jyoti P Patil (PI). The results of the Jashpur and Kanker district by LVI-IPCC approach on block level assessment were presented. Moreover, results by composite LVI methodology on wastershed scale were also presented. It was informed that the computation methodology will be incorporated in Decision Support System- Hydrology (DSS-H) under Neeranchal project. The committee member asked

		about source of village/ district boundaries consider in the computation. In her reply, it was informed that spatial data for village/ district boundaries from Survey of India is under procurement, at present the data provided by State Level Nodal Agencies (SLNA) is considered for this study. There were no specific comments on results of the study.
5.	**Hydrological modelling in Bhagirathi basin up to Tehri dam and assessment of climate change impact** **Team:** A R Senthil kumar, J. V. Tyagi, M. K. Goel, S. D. Khobragade, P. C. Nayak, Manohar Arora and Digambar Singh DOS: July 2016, DOC: June 2021 (**NMSHE**)	The objectives, brief methodology and present status of the study were presented by Dr. A. R. Senthil kumar (PI). The PI mentioned that the discharge and sediment yield at Tehri dam was simulated using SWAT by considering the parameters randomly initially and input data obtained/generated from different sources such as, NASA, BHUVAN NRSC, NBSSLUP, ECMWF. The paramters for the simualtion of discharge were calibrated using SWAT CUP and the data from 2001 to 2013 and the metrorological data from both IMD and ERA Interm (ECMWF). Dr. D. K. Singh inquired about the range of parameters. The PI mentioned that the results during calibraion and validation measured by the performance indicators were poor because of poor quality of hydro-meteorological data. The chairman suggested to contact THDC authority to get good quality data.
6.	**Development of water allocation plan for a Neeranchal watershed in Chhattisgarh** **Team:** A. R. Senthil Kumar, Jyoti P Patil, T R Nayak and Rajesh Agarwal DOS: Apr 2018, DOC: March 2020	The objectives, methodology and status of the study were presented by Dr. A. R. Senthil kumar (PI). PI mentioned that the WEAP model has been setup for micro watersheds IWMP14, IWMP15 and IWMP16 of Kanker District, Chhattisgarh. The climate data was donwloaded from WEAP site. Model outputs such as water demand, runoff generated, demand site inflows and outflows, unmet demand, reliability of demand met were presented for the period from 2008 to 2025. Dr. D. R. Sena inquired about the method used in the computation of runoff. The PI informed that the runoff was computed by the soil moiture model of WEAP.
7	**Rejuvenation of village ponds for identified villages in Muzaffarnagar and Meerut districts** **Team:** V C Goyal, Omkar Singh, Rajesh Singh, Digambar Singh **Scientific/Technical Staff:** Subhash Kichlu, Rajesh Agarwal, Rakesh Goyal, N. R. Allaka, N. G. Shrivastava, Nihal Singh, Kalzang Mathus, Sandeep Yadav, Subhash Vyas DOS: April 2017, DOC: March 2020	The objectives, brief methodology and present status of the civil work related to rejuvenation of ponds, being taken up by NPCC Ltd., was presented by Er. Omkar Singh. There were no specific comments from working group members.
8	**Rejuvenation of Village Ponds in Identified Villages of Baghpat, Ghaziabad and Meerut Districts of Uttar Pradesh** **Team:** Omkar Singh, Rajesh Singh, V. C.	Er Omkar Singh (PI) informed that the civil work for rejuvenation work of ponds under this project has been iniated, and baseline data collected during field investigations was presented. There were no specific comments from working group members.

	Goyal, Digambar Singh **Scientific/Technical Staff:** Subhash Kichlu, Rajesh Agarwal, Rakesh Goyal, N. R. Allaka, N. G. Shrivastava, Nihal Singh, Kalzang Mathus, Sandeep Yadav, Subhash Vyas DOS: March 2018, DOC: March 2021	

Dr. V C Goyal thanked the members for their valuable contributions during deliberations in the Working Group meeting.

The meeting ended with vote of thanks to the Chair.

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APPENDIX 72.5.2

MINUTES OF THE 48th MEETING OF THE WORKING GROUP OF NIH

MINUTES OF THE
48TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING 2-3 MAY 2019

The meeting was held under the Chairmanship of Dr. S K Jain, Director, NIH. The list of participants of the meeting is given in Annexure-I.

ITEM NO. 48.1: OPENING REMARKS BY THE CHAIRMAN

Chairman, WG, welcomed the WG members and the Scientists of NIH. He informed about the Foundation Day celebration of NIH in December 2018 and the special publications prepared by NIH. He mentioned about a NIH publication entitled 'Climate change and its impacts on water resources of India'. He requested the members to suggest topics for such publications in key areas, and indicate their willingness to collaborate with NIH in this endeavour. He informed about the organization of a conference in Hindi in December 2019, and requested the members to actively participate in it. Also, he desired frequent interaction of NIH scientists with the WG members on specific studies.

The Chairman then requested the WG 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. Wasim Ahmed	▪ Collaboration with NIH on spring rejuvenation program
2.	Dr. K V Singh	▪ Site tour of WG members on ongoing/completed studies
3.	Dr. R D Deshpande	▪ Objectives of some studies not carefully formulated ▪ Preparation of PPTs needs improvement ▪ Not all studies need to be presented in every meeting ▪ All NIH scientists should be present during the deliberations ▪ Data interpretation workshops should be organized among NIH groups with participation of concerned WG member(s) ▪ NIH may plan a new program on Hydromatics ▪ NIH may bring out a report on 'Hydrologic processes in Himalayas' ▪ NIH may organize an International Symposium on 'Advances in Hydrologic Research'
4.	Dr. S P Aggarwal	▪ NIH's may contribute more to solve real world water problems
5.	Dr. R K Goyal	▪ Need for time management in presenting studies ▪ Overlap of scientists in many studies ▪ Mentioned ICAR's guidelines on scientists involvement in studies
6.	Dr. Man Singh	▪ Emphasised on data availability
7.	Prof. A K Saraf	▪ Change detection is an important consideration in many studies
8.	Prof. M L Kansal	▪ Requested for active participation in Roorkee Water Conclave 2020
9.	Dr. S S Grewal	▪ Water recharge and allocation planning in industrial belt of Aravalli hills ▪ Drying of springs in Shiwaliks and Arvallis ▪ Lesser number of studies should be presented ▪ Pond rejuvenation work to be widely publicized
10.	Dr. Kaushal K. Garg	▪ Collaborative work with NIH on watershed interventions ▪ Consider Ecosystem Services as part of hydrology studies ▪ While working out climate change scenarios, include landuse changes along with precipitation and temperature
11.	Prof. Ramakar Jha	▪ Prepare e-books ▪ Work for patents ▪ Sponsored projects need not be presented in detail

12.	Prof. A P Dimri	▪ Establishment of High Performance Computing Centre ▪ Avoid duplication of studies among Divisions of NIH ▪ Organize workshop on 'Statistical interpretation of hydrologic data' ▪ Organize national workshop on 'Rejuvenation of village ponds' ▪ Plan new programs on 'Hydrology for atmosphere-land-underground' and 'Hydrologic regimes of India' ▪ Understanding of processes is important while selecting a model ▪ Highlight societal aspects of NIH's work
13.	Dr. Sadhana Malhotra	▪ Success stories need to be documented and disseminated ▪ Presentation skills need improvement
14.	Sh. Sudhindra Mohan Sharma	▪ More training programs for field engineers ▪ More interaction with industry
15.	Dr. Anil Guatam	▪ Collaboration with NIH on spring rejuvenation program

Next, the Chairman asked the Member-Secretary to take up the agenda.

ITEM No. 48.2: CONFIRMATION OF THE MINUTES OF 47th MEETING OF THE WORKING GROUP

The 47th meeting of the Working group was held during 23-24 October 2018. The minutes of the meeting were circulated to all the members and invitees vide letter No. RMOD/WG/NIH-10 dated 04 December 2018. The members confirmed the minutes of the 47th Working Group meeting.

ITEM No. 48.3: 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 47th working group meeting.

ITEM Nos. 48.4 & 48.5: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR YEAR 2018-19 AND FINALIZATION OF THE WORK PROGRAMME FOR YEAR 2019-20.

The Member-Secretary requested the respective Divisional Heads to present the progress of studies carried out during 2018-19 and proposed work program for the year 2019-20. Accordingly, the progress of various studies and sponsored projects was presented by all Scientific Divisions during the two day deliberations of the Working Group. The Division wise minutes of each study/project presented during the meeting are given next.

ENVIRONMENTAL HYDROLOGY DIVISION

Dr. J.V. Tyagi, Scientist 'G' & Head of EHD presented a brief overview of the Division including scientific manpower, status of studies, consultancy projects, publications, and technology transfer activities. Thereafter the scientists of the Division presented the progress of their studies and the comments/suggestions received from the Working Group members are summarized below.

Progress of Work Program for 2018-19

SN	Study	Recommendations/Comments
	Internal Studies (Continuing)	
1.	Development of Habitat Suitability Curves for the Aquatic Species of Western Himalayan Streams and Assessment of Environmental Flows **Study Group:** Pradeep Kumar (PI) and C. K. Jain Duration: 3 Years (04/16-05/19)	Dr. Pradeep Kumar presented the study and there were no comments.
2.	Impact of Climate Change on Runoff and Sediment Yield for Puthimari Tributary of River Brahmaputra **Study Group:** Swapnali Barman (PI), J. V. Tyagi, & R.K. Bhattacharya (IITG) Duration: 3 Years (11/18-10/21)	Dr. Swapnali Barman presented the study and following suggestions were made. • Dr. A. P. Dimri suggested to calculate variations in % and use hybrid ANN-SWAT model. • Dr. A. K. Saraf suggested to use void free data. *Note: Due to transfer of PI to CFMS Guwahati, the study is transfered to CFMS Guwahati.*
	Sponsored Projects (Continuing)	
3.	Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin **Study Group:** C.K. Jain (PI), Manohar Arora, M. K. Sharma, Pradeep Kumar, R. Singh, & D. S. Malik (GKU) **Sponsored by:** DST (NMSHE) **Project Cost:** Rs. 2.25 Crore **Duration:** 5 Years (04/16-03/21)	Dr. M. K. Sharma presented the study and following suggestions were made: • Dr. Anil Gautam suggested to explore indexing of water quality based on biological parameters.
4.	Ground Water Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District of Chhattisgarh State and Ameliorative Measures **Study Group:** M. K. Sharma (PI), C.K. Jain, Surjeet Singh, & Pradeep Kumar **Partner:** WRD, Raipur & CGWB, Raipur **Sponsored by:** NHP-PDS **Project Cost:** Rs. 25.4 Lakh **Duration:** 03 Years (09/17-08/20)	PI Dr. M. K. Sharma presented the study and following suggestions were made: • Dr. Deshpandey enquired about the criteria for selection of sampling sites considering the aquifer geometry. Dr. Sharma replied that the sampling sites were selected on the basis of wells connected to different aquifers, which are continuously being observed either by WRD, Raipur or CGWB. • Dr. Dimri wanted to know the causes of the dilution of water quality parameters. Dr. Sharma supplemented that rainfall and surface irrigation may be the causes of dilution. • Dr. Jha advised to use same colour combination for pre- and post-monsoon data presentation to have more visibility of dilution effect.
5.	Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures	PI Dr. Rajesh Singh presented the study and following suggestions were made:

	Study Group: Rajesh Singh (PI), Pradeep Kumar, M. K. Sharma, & Sumant Kumar **Partner:** Water Resources Organization, Punjab **Sponsored by:** NHP-PDS **Project Cost:** 65.6 Lakh **Duration:** 3 Years (09/17 – 08/20)	• Dr. S.S. Grewal suggested collecting the samples from the villages/locations in depressions.

WORK PROGRAM FOR THE YEAR 2019-20

SN	Study	Study Team	Duration/Status
Internal Studies (Continuing)			
1.	Development of Habitat Suitability Curves for the Aquatic Species of Western Himalayan Streams and Assessment of Environmental Flows	Pradeep Kumar (PI)	3 Years (04/16-05/19)
Internal Studies (New)			
2.	Water Quality Assessment of Haridwar District	R.K. Nema (PI) Rajesh Singh, J. V. Tyagi Pradeep Kumar	3 years (05/19-04/22)
Sponsored Projects (Continuing)			
3.	Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin	M. K. Sharma (PI) Manohar Arora, Pradeep Kumar, Rajesh Singh D. S. Malik (GKU)	5 Years (04/16-03/21) Sponsored by: DST (NMSHE)
4.	Ground Water Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District of Chhattisgarh State and Ameliorative Measures	M. K. Sharma (PI) Surjeet Singh, Pradeep Kumar Partner: WRD, Raipur, CGWB, Raipur	3 Years (09/17-08/20) Sponsored by: NHP-PDS Project Cost: Rs. 25.4 Lakh Status: In-progress
5.	Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures	Rajesh Singh (PI) Pradeep Kumar, M. K. Sharma, Sumant Kumar **Partner:** Water Resources Organisation, Punjab	3 Years (09/17-08/20) Sponsored by: NHP-PDS Project Cost: Rs. 65.6 Lakh Status: In-progress
Sponsored Projects (New)			
6.	Leachate Transport Modeling for Gazipur landfill site for suggesting ameliorative measures	Anjali (PI) Sudhir Kumar, J. V. Tyagi, M. K. Sharma, Nitesh Patidar **Partner:** CGWB (Delhi unit)	3 Years Project cost: Rs. 76.10 Lakh Status: PDS proposal submitted to NHP, yet to be approved by Review committee
7.	Study of Emerging Pollutants and Geochemical Processes Responsible for the Groundwater Contamination in and around Raipur Agglomerate, Chhattisgarh and Suggestive Ameliorative Measures	M. K. Sharma (PI) J. V. Tyagi Surjeet Singh Pradeep Kumar Rajesh Singh WRD, Raipur	3 Years Project cost: Rs. 77.32 Lakh Status: PDS proposal submitted to NHP, yet to be approved by Review committee

Proposed Training Programmes during 2019-20

SN	Topic	Duration	Place
1.	Hydrologic Modelling using SWAT (Coordinator: Dr. J. V. Tyagi)	Two weeks 20-31 May 2019	Roorkee
2.	Ground Water Quality Monitoring & Assessment under NHP-PDS (Coordinator: Dr. M. K. Sharma)	5 Days 3-7 June 2019	Roorkee
3.	Water Quality Assessment & Management under NHP-PDS (Coordinator: Dr. Rajesh Singh)	5 Days 17-21 June 2019	Roorkee
4.	Water Quality: Concepts and Analysis under NHP (Coordinator: Dr. Pradeep Kumar)	5 Days Oct. 2019	Roorkee

GROUND WATER HYDROLOGY DIVISION

Mr. C. P. Kumar, Scientist 'G' & Head presented a brief overview, status of studies and activities carried out by the division. He informed that one in-house R&D study and ten sponsored studies were approved for the year 2018-19. Out of these, the in-house R&D study was dropped due to various issues in customization because the designed system was not allowing the level of customization. He also informed that since suitable land could not be made available for the study "*Grey Water to Blue Water – Natural Treatment Techniques for Transforming Wastewater into Sustainable Useable Water*", this study has been dropped. In addition, scientists of the division have a major role in activities of NHP such as coordinating the Purpose Driven Studies (PDS) of all implementing agencies of NHP, DSS planning and management in selected states, development of groundwater module for "*Integrated Hydrologic Model*" with IIT Kharagpur and procurement.

The study-wise progress was presented by respective Principal Investigators and emerged suggestions are given below.

12. Project Code: NIH/GWH/NIH/15-19: **Peya Jal Suraksha - Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply**

Dr. Surjeet Singh (PI) briefed about the study and progress made during the last six months. He informed that Phase-I works at the four sites; Agra and Mathura in U. P. along Yamuna river, Berhara village in Ara district in Bihar along the Ganga river, and Varaha river at Visakapatnam have been completed through respective state water supply departments. He informed that Phase-II works are partly completed for the Agra and Mathura sites involving the installation of submersible pumps, the establishment of a pump house, etc. For the other two sites, Ara and Visakapatnam, the Phase-II works are likely to start through the respective state government departments.

13. Project Code: NIH/GWH/BGS/17-20: **Groundwater Fluctuations and Conductivity Monitoring in Punjab - New Evidence of Groundwater Dynamics in Punjab from High Frequency Groundwater Level and Salinity Measurements**

Dr. Gopal Krishan presented the results for variation in water level indicating different times of fluctuation thereby ascertaining the relationship between deep and shallow aquifers and also indicated the recharge sources.

14. Project Code: NIH/GWH/NMSHE/16-20: **Study of River - Aquifer Interactions and Groundwater Potential at Selected Sites in the Upper Ganga Basin up to Dabrani**

Dr. Surjeet Singh presented the progress of the study during the last six months. He also described the status of installation of piezometers being developed, water sampling and analysis being carried out, future plans and presented the results of water quality and isotopic analysis.

15. Project Code: NIH/GWD/NIH/16-19: **Grey Water to Blue Water – Natural Treatment Techniques for Transforming Wastewater into Sustainable Useable Water**

This study was dropped.

16. Project Code: NIH/GWH/DST/18-20: **Future Secular Changes and Remediation of Groundwater Arsenic in the Ganga River Basin - FAR GANGA**

Dr. Surjeet Singh presented the progress made so far. He informed that the project is of 4 x 4 consortium partner from each country and the Indian partners are NIH (Indian Lead); IIT Kharagpur; IIT Roorkee; and Mahavir Cancer Sansthan, Patna and UK partners are University of Manchester (UK Lead), British Geological Survey, Salford University; and University of Birmingham. While presenting the objectives and hypotheses to be tested in the project, he also explained the future plans.

17. Project Code: NIH/GWH/DST/18-20: **Impact of Rainwater Harvesting on Groundwater Quality in India with Specific reference to Fluoride and Micro-pollutants**

Dr. Anupma Sharma presented the research gaps, objectives of the study, and the work packages. The study sites in which field investigations are being conducted were discussed. It was informed that a few more sites besides Laporiya watershed are being surveyed that would be taken up for research investigations.

18. Project Code: NIH/GWH/PDS/17-21: **Ganges Aquifer Management in the Context of Monsoon Runoff Conservation for Sustainable River Ecosystem Services - A Pilot Study**

Dr. Surjeet Singh presented the objectives, progress of work and future plans of the study. Dr. Ramakar Jha enquired about the selection of the Sot river catchment which was replied by Dr. Singh.

19. Project Code: NIH/GWH/PDS/17-21: **Assessment of Impacts of Groundwater Salinity on Regional Groundwater Resources, Current and Future Situation in Mewat, Haryana – Possible Remedy and Resilience Building Measures**

Dr. Gopal Krishan presented the background, statement of the problem, objectives, methodology, progress and future plans of the study.

20. Project Code: NIH/GWH/PDS/17-20: **Hydro-geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin**

Mr. Sumant Kumar presented the objectives, methodology, achievements and expected outcome of the study. The Chairman, Working Group suggested doing sampling in the other side of Ganga river to know the present situation of Arsenic contamination.

21. Project Code: NIH/GWH/CEHM/18-22: **Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin up to Delhi**

Dr. Anupma Sharma presented the special study taken up under the Centre of Excellence for Hydrologic Modeling in NHP. The project entails large data processing, field investigations and modeling pertaining to surface water and groundwater flows, contaminant transport and water resources management. The progress made in respect of data collection and processing, field experiments and hydrologic modeling was presented. It was informed that in view of the large study area, satellite data would be used to the extent possible. Field investigations and laboratory experiments are planned to build up the soil parameters database. The working group members expressed concern about the decline in groundwater levels in certain areas of the eastern and western Yamuna canal commands. It was informed that except in salinity affected areas, groundwater pumpage has increased during the last two decades. However, groundwater withdrawal data are not readily available and would be collected through field surveys.

22. Project Code: NIH/GWH/NIH/18-19: **Application for Conjunctive Use Management of Surface Water and Groundwater in Saryu Nahar Pariyojna, U.P. using "Strategic Basin Planning for Ganga River Basin"**

This study was dropped.

23. Project Code: NIH/GWD/NIH/19-21: **Assimilation and Application of Satellite Data Products for Water Resources Assessment of Inland River Basins of India**

Ms. Suman Gurjar presented the background, objectives, methodology, and expected outcome of the study. Dr. A. P. Dimri suggested changing the title of the study because the assimilation techniques are not being used in this study. Therefore, the title of the study has been changed as "*Application of Satellite Data Products for Water Resources Assessment*". He also suggested that to begin with, an area in the Ganga basin can be used as a study area. He also indicated that the estimation of the land surface temperature using satellite data can be a great output. Dr. S. P. Aggarwal suggested getting the basic information of satellites which are providing the data. He also suggested defining the methodology. The Chairman, WG suggested to start with the water balance equation and consider all major processes.

24. Project Code: NIH/GWH/NIH/19-22: **Integrated Hydrological Modelling to Investigate the Surface-Subsurface Water Interactions**

Mr. Nitesh Patidar presented the background, objectives, methodology, and expected outcome of the study. Dr. S. M. Sharma indicated that finding the information related to the aquifer geometry of the study area will be a complex task as it is dominated by basalt rocks.

The work program of the division for the year 2019-20, as recommended by the Working Group below:

WORK PROGRAM FOR THE YEAR 2019-20

S. No.	Project	Project Team	Duration & Status	Funding Source
		Internal Studies		
1. NIH/GWH/NIH/19-21	Application of Satellite Data Products for Water Resources Assessment	Suman Gurjar (PI), Vishal Singh, Surjeet Singh, C. P. Kumar, P. K. Singh	2 years (05/19 - 04/21) *Status: In progress*	Internal Study
		Sponsored Projects		
2. NIH/GWH/NIH/15-19	Peya Jal Suraksha - Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply	Surjeet Singh (Lead), B. Chakravorty, Y. R. S. Rao, Anupma Sharma, Sumant Kumar, Gopal Krishan, Suman Gurjar, Anju Chaudhary, Sanjay Mittal	2.5 years (11/15–12/19) Extended till Dec. 2019 *Status: In progress*	Sponsored by MoWR, RD & GR under Plan Fund
3. NIH/GWH/NMSHE/16-20	Study of River - Aquifer Interactions and Groundwater Potential at Selected Sites in the Upper Ganga Basin up to Dabrani	Surjeet Singh (PI), C. P. Kumar, R. J. Thayyen, Sudhir Kumar, Manohar Arora, Gopal Krishan, Nitesh Patidar, Anjali	5 years (01/16 - 12/20) *Status: In progress*	Sponsored by DST under NMSHE SP-8

4. NIH/GWH/BGS/17-20	Groundwater Fluctuations and Conductivity Monitoring in Punjab - New Evidence of Groundwater Dynamics in Punjab from High Frequency Groundwater Level and Salinity Measurements	Gopal Krishan (PI), Surjeet Singh, C. P. Kumar *From: BGS, UK* Dr. Dan Lapworth (PI) Prof. Alan MacDonald	3 years (12/17-11/20) *Status: In progress*	Sponsored by BGS, UK
5. NIH/GWH/PDS/17-20	Hydro-geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin	Sumant Kumar (PI), Sudhir Kumar, Rajesh Singh, Gopal Krishan, Anju Chaudhary *Partner Organization:* MWRD, Bihar *Collaborator:* Brijesh Yadav, IIT Roorkee and N.S Maurya, NIT Patna	3 years (12/17-11/20) *Status: In progress*	Sponsored by NHP under PDS
6. NIH/GWH/PDS/17-21	Assessment of Impacts of Groundwater Salinity on Regional Groundwater Resources, Current and Future Situation in Mewat, Haryana – Possible Remedy and Resilience Building Measures	Gopal Krishan (PI), Surjeet Singh, C. P. Kumar, S. K. Verma *IIT-Roorkee:* M. L. Kansal, Brijesh Yadav (PI) *Sehgal Foundation, Gurgaon:* Lalit Mohan Sharma	3 years (12/17-11/21) *Status: In progress*	Sponsored by NHP under PDS
7. NIH/GWH/PDS/17-21	Ganges Aquifer Management in the Context of Monsoon Runoff Conservation for Sustainable River Ecosystem Services - A Pilot Study	Surjeet Singh (PI), C. P. Kumar, Sudhir Kumar, Suman Gurjar, Gopal Krishan	4 years (12/17-11/21) *Status: In progress*	Sponsored by NHP under PDS
8. NIH/GWH/DST/18-20	Future Secular Changes and Remediation of Groundwater Arsenic in the Ganga River Basin - FAR GANGA	B. Chakravorty (India Lead), Surjeet Singh (Dy. Lead), Sumant Kumar, Gopal Krishan, Suman Gurjar *Other India Partners:* IITR, IITKg, MCS, Patna *UK Partners:* Univ. of Manchester, BGS, Salford University, Univ. of Birmingham	3 years (01/18 - 12/20) *Status: In progress*	DST-Newton Bhabha-NERC-India-UK Water Quality Research Programme

9. NIH/GWH/DST/18-20	Impact of Rainwater Harvesting on Groundwater Quality in India with Specific Reference to Fluoride and Micro-pollutants	Anupma Sharma (Indian Lead), Sumant Kumar, Gopal Krishan, Suman Gurjar, M. K. Sharma *Other Indian Partners:* IIT Ropar, IIT Jodhpur *UK Partner:* Cranfield University School of Water, Energy and Environment; Cranfield University *Project Partners:* Wells for India and Excellent Development, UK based NGOs together with their Indian offices and local NGO partners in Rajasthan	3 years (01/18 - 12/20) *Status: In progress*	DST-Newton Bhabha-NERC-India-UK Water Quality Research Programme
10. NIH/GWH/CEHM/18-22	Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin up to Delhi.	Anupma Sharma (PI) Sanjay K. Jain, Archana Sarkar, M. K. Sharma, L. N. Thakural, Sumant Kumar, Suman Gurjar, Vishal Singh, Nitesh Patidar *Partner Organization:* C.E, IWRD Haryana, Tech. Coord., GWD UP, S.E. YBO, CWC New Delhi	4 years (04/18-03/22) *Status: In progress*	Special Project under "Centre of Excellence" (NHP)
11. NIH/GWH/DST/19-23	Enhancing Food and Water Security in Arid Region through Improved Understanding of Quantity, Quality and Management of Blue, Green and Grey Water	Anupma Sharma (Lead NIH), Nitesh Patidar (Lead: CAZRI Jodhpur, Partner: NIH)	4 years (03/19 - 02/23) *Status: In progress*	Sponsored by DST
12. NIH/GWH/NMCG/19-20	Environmental Flow Assessment for Yamuna River from Hathnikund Barrage to Okhla Barrage	Anupma Sharma (PI), Sharad K. Jain, Manohar Arora, Pradeep Kumar, Rajesh Singh, Vishal Singh	1 year (04/19 - 03/20) *Status: In progress*	Sponsored by NMCG
13. NIH/GWH/MoES/19-19	Improving our Understanding of the Aquifer Systems in Sunderbans	Gopal Krishan (PI), C. P. Kumar (Co-PI)	5 months (05/19 - 09/19) *Status: In progress*	Sponsored by India-UK Water Centre (MoES & NERC)
Other R & D Projects				
15.	Development of Groundwater Model for Integrated Hydrologic Model	Anupma Sharma, B Chakravorti, Surjeet Singh, Suman Gurjar, Sumant Kumar, Nitesh Patidar	3 years (08/18 -07/21) *Status: In progress*	CEHM, NHP
16.	DSS Planning & Management in Selected States	Anupma Sharma, D S Rathore and Team	6.5 years (06/19 -11/25) *Status: to start*	NHP

HYDROLOGICAL INVESTIGATIONS DIVISION

Dr Sudhir Kumar, Scientist-G and Head of the H. I. Division presented the brief details of the Division including the scientific staff strength and infrastructure. He briefly introduced about the scientific work of the Division and the various studies being carried by the Division including the new proposals, along with details about the publications by the Division and analytical work carried out at the Nuclear Hydrology Laboratory. He also made a brief presentation on Hydrology for Disaster management wherein the case study related to NIH involvement and hydrological investigation for the management of mining disaster in Meghalaya was presented.

Table 1: Status of studies carried out by HI Division during 2018-19

Type of study/Project	*Completed during 2018-19*	*Continuing in 2019-20*	*Total*
Internal Studies	-	-	-
Sponsored Projects	0	6	6
Consultancy Projects	5	4	9
Total	5	10	15

Table 2: Training Courses/Workshops organised by HI Division during 2018-19

S.N.	Title of Training Course/Workshop	Duration	Venue
1.	Training Workshop on "Interpretation of Isotopic Data for Aquifer Mapping" for CGWB Officials	5 days 30 July-3 August, 2018	NIH Roorkee
2.	Training Workshop on "Interpretation of Isotopic Data for Aquifer Mapping" for CGWB Officials	5 days 27th August to 31st August, 2018	NIH Roorkee
3.	Training Workshop on "Environmental Isotopes for Climate Resiliency of Mountain Watersheds" Government Officials of Nepal.	5 days 22-26 October, 2018	NIH Roorkee
4	Training Workshop on "Coastal Zone Water resources: Challenges Investigation Techniques and Management"	11-15 February, 2019	NIH Roorkee

Table 3: Details of samples analysed by HI Division Labs during 2018-19

S.N.	Parameter analysed	No. of samples
1	δ^{2}H on DI-IRMS	6996
2	δ^{18}O on DI-IRMS	919
3	δ^{18}O on CF-IRMS	5653
4	Tritium	310
5	WQ samples on IC	950

Table 4: Details of Research Publications by HI Division during 2018-19

	Published	**Accepted**	**Communicated**
Books/Book Chapter	2	-	-
International Journals	8	4	8
National Journals	-	-	-
International Conferences	3	-	-
National Conferences	-	-	-

Table 5: Details of important instruments purchased by HI Division during 2018-19

S.N.	Name of Instruments	Approximate Cost
1	Normal Scintillation Counter	27 lakh
2	CHNS element analyser	47 lakh
3	DWLRs	5 lakh
4	WL Indicators	1.5 lakh

The progress of each individual study for the year 2018-19 was presented by the respective P.I. of the study. The comments/actions suggested by the working group for various studies are as follows:

INTERNAL STUDIES: Nil

SPONSORED PROJECTS:

SN	Project	Duration	Funding	Status	Comments/ Action(s) Suggested
1.	Understanding of hydrological processes in Upper Ganga basin using isotopic techniques	5 Years (04/16-03/21)	NMSHE Project	Continuing Study	i) Dr. R. D. Deshpande suggested that isotopic signatures may be correlated with meteorological data. ii) Dr. R. D. Deshpande suggested that efforts be made to measure discharge of some springs.
2.	Rejuvenation of Springs and Spring-fed Streams in Mid-Himalayan Basin using Spring Sanctuary concept	3 Years (06/16 - 05/19)	Project with GBPIHE	Continuing Study	No specific action suggested
3.	Dating very old ground waters of deeper aquifers in Ganga Plains, India	3 Years (06/16 - 05/19)	IAEA	Continuing Study	No specific action suggested
4.	Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin	3 ½ year (1/18 – 6/21)	PDS under NHP	Continuing Study	No specific action suggested
5.	Integrated Study on groundwater dynamics in the coastal aquifers of West Bengal for sustainable groundwater management	3 ½year (1/18 – 6/21)	PDS under NHP	Continuing Study	No specific action suggested
6.	Development of a comprehensive plan for conservation and sustainable management of Bhimtal and Naukuchiatal lakes, Uttarakhand	3 Years (1/18 – 12/20)	PDS under NHP	Continuing Study	No specific action suggested
7.	Climate resilient conservation & data management of spring water sources by strengthening monitoring mechanisms in drought prone areas of Sikkim	6 months (11/18-4/19)	Proposed to be funded by UNDP	Had to be dropped due to delay in approval	--

Besides the progress of the studies for 2018-19, two new studies proposed under the work programme of the Division for the year 2019-20 were presented by the respective PIs. The comments/actions suggested by the working group for these studies are as follows:

SN	Project	Duration	Funding	Status	Comments/ Action(s) Suggested
1.	Integrated hydrological investigations of natural springs in lesser Himalaya, Uttarakhand	3 years (04/10-03/22)	Internal	New	Director, NIH suggested to include Dr. S.S. Grewal in the project and involve more area from Siwalik region
2.	Isotope fingerprinting of precipitation over Indian Region	3 years (04/10-03/22)	Internal	New	Dr. Dimri suggested to include Odisha like Bhubaneswar and Shimla may be included for monitoring.

APPROVED WORK PROGRAMME FOR 2019-20

SN.	Project Title	Study Team	Duration	Remarks
INTERNAL STUDIES:				
1	Integrated hydrological investigations of natural water springs in lesser Himalaya, Uttarakhand	S M Pingale (PI), Sudhir Kumar, S. D. Khobragade, Soban Singh Rawat, Rajeev Gupta	3 years (04/19-03/22)	New Study
2	Isotope fingerprinting of precipitation over Indian Region	Nidhi Kalyani (PI) Sudhir Kumar, MS Rao; Scientists from RC's	3 years (04/19-03/22)	New Study
SPONSORED PROJECTS:				
1.	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	Suhas Khobragade (PI), Sudhir Kumar, Rajesh Singh, M. Arora, R. J. Thayyen, S.K. Verma	5 Years (04/16-03/21)	Continuing Study under NMSHE Project
2.	Rejuvenation of Springs and Spring-fed Streams in Mid-Himalayan Basin using Spring Sanctuary concept	Sudhir Kumar (PI) S.K. Verma	3 Years (06/16 -05/19)	Continuing Study Project with GBPIHE
3.	Dating very old ground waters of deeper aquifers in Ganga Plains, India	MSRao (PI) Sudhir Kumar, S.K. Verma	3 Years (06/16 -05/19) Extended till Dec. 2021	Continuing Study IAEA under CRP
4.	Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin	Sudhir Kumar (PI) M.K. Sharma, M. Someshwar Rao,	3 ½ year (1/18 – 6/21)	Continuing Study PDS under

		S.K. Verma		NHP
5.	Integrated Study on groundwater dynamics in the coastal aquifers of West Bengal for sustainable groundwater management	M. Someshwar (PI), Sudhir Kumar, S.K. Verma, Nidhi Kalyani, V. S. Jeyakanthan	3 ½year (1/18 – 6/21)	Continuing Study PDS under NHP
6.	Development of a comprehensive plan for conservation and sustainable management of Bhimtal and Naukuchiatal lakes, Uttarakhand	Suhas Khobragade, Sudhir Kumar	3 Years (1/18 – 12/20)	Continuing Study PDS under NHP
7.	Unravelling Submarine Discharge (SGD) zones along the Indian subcontinent and its islands (Mission SGD) – Pilot Study	Sudhir Kumar, MS Rao, Nidhi Kalyani BK Purandra YRS Rao	1 year (04/19 – 03/20	MoES through NCESS

SURFACE WATER HYDROLOGY DIVISION

WORK PROGRAMME FOR THE YEAR 2019-20

ONGOING STUDIES (SPONSORED)			
S. No. & Ref. Code	**Title**	**Study Team**	**Duration**
1.NIH/SWHD/17-20	Water efficient Irrigation by using SCADA system for medium irrigation Project (MIP) Shahnehar (PDS-NHP).	R.P. Pandey J.P. Patra Rajesh Singh N.K. Bhatnagar	3 years (Dec 2017 to Dec 2020)
2.NIH/SWHD/16-21	Hydrological modeling in Alaknanda basin and assessment of climate change impact (NMSHE).	A.K. Lohani Sanjay K. Jain Archana Sarkar V.S. Jeyakanthan L.N. Thakural	5 years (April 2016 to March 2021)
ONGOING STUDIES (INTERNAL)			
S. No. & Ref. Code	**Title**	**Study Team**	**Duration**
3.NIH/SWHD/17-21	Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin (3f)	Sanjay Kumar Rakesh Kumar J.P. Patra Pankaj Mani	4 years (April 2017 to March 2021)
4.NIH/SWHD/15-19	Study of hydrological changes in selected watersheds in view of climate change in India	L.N. Thakural D.S. Rathore Surjeet Singh Sanjay K. Jain Sharad K. Jain	4 years (April 2015 to March 2019) extended up to March 2020
5.NIH/SWHD/17-20	Development of regional methods for design flood estimation in Uttarakhand	J.P. Patra Rakesh Kumar Pankaj Mani Sanjay Kumar	3 years (April 2017 to March 2020)

6.NIH/SWHD/18-21	Evaluation of seasonal extreme rain events across river basins of India in 3D global temperature change scenario	Ashwini Ranade Archana Sarkar	3 years (April 2018 to March 2021)
7.NIH/SWHD/18-20	Assessment of climate change impact on water availability and agriculture in part of Banas basin.	Archana Sarkar Surjeet Singh Suman Gurjar Sunil Gurrapu	2 years (Nov 2018 to October 2020)
8.NIH/SWHD/18-21	Evaluation of the influence of low- frequency atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent.	Sunil Gurrapu Ashwini Ranade J.P. Patra	3 years (Nov 2018 to March 2021)
9.NIH/SWHD/18-20	Evaluation of water quality of Government schools in Roorkee block, District Haridwar	N.K. Bhatnagar M.K. Sharma L.N. Thakural	2 years (Oct 2018 to Sept. 2020)

NEW STUDIES (INTERNAL)			
S. No. & Ref. Code	**Title**	**Study Team**	**Duration**
10.NIH/SWHD/19-22	Development of drought monitoring system for early warning and preparedness for a selected region in India	R.P. Pandey, D.S.Rathore, Ravi Galkate, Sunil Gurrapu	Proposal to be revised based on comments in the 48th Working Group meeting

S.N.	**Title of Project/ Study, Study Group, Start/ Completion Dates**	**Status and Recommendations/Suggestions**
SPONSORED STUDIES		
1.	Water efficient irrigation by using SCADA system for medium irrigation project (MIP) Shahnehar (Ongoing) PDS under NHP. **StudyGroup:** R.P. Pandey J. P. Patra Rajesh Singh N.K. Bhatnagar **DOS:** Dec. 2017 **DOC:** Dec. 2020	Dr. R.P. Pandey (PI) presented progress of the study. He informed that the NIH team has conducted field investigations in the Shahnehar command area and three experimental sites identified as follows: (i) Lift Irrigation Scheme (LIS) at Sathana Vilage, Terrac Sub-Division, (ii) field plots in distributary-1 (D-1) command area – at Riyali village, Badukhar Sub-Division and (iii) distributary-2 (D-2) command area- at Kathghar village. Dr Man Singh suggested to consider suitable optimum size of furrow length or check basin in field water application. Dr. Amrish Tiwari, IISWC, suggested to monitor flows in canal system for precise assessment and quantification of losses. Dr SS Grewal informed that the land leveling and shaping is one of the very important components in irrigation water saving. Therefore, the farmers should be convinced level their fields to improve irrigation water use efficiencies. It was informed that the conveyance system in Shahnehar command areas are lined have high conveyance efficiency.

2.	Hydrological modeling in Alaknanda basin and assessment of climate change impact (Ongoing). **Study Group:** A.K. Lohani Sanjay K. Jain Archana Sarkar V.S. Jeyakanthan L.N. Thakural **DOS:** Jan. 2016 **DOC:** Dec. 2020	Dr A.K. Lohani presented the progress of the study. He informed that all the required spatial and temporal data for the study have been prepared. Flow data of various gauging sites and meteorological data have been collected from CWC, and processing of the data is in progress. VIC model has been setup for the study basin and calibration and fine-tuning of the model with the available data is in progress. He mentioned that the climate projection data are required to project impact of climate change on river flow. Projection data is to be generated through another NMSHE study and utilized.

INTERNAL STUDIES		
3.	Development of regional relationships for water availability analysis and flood estimation for lower Godavari basin (3f) (Ongoing). **Study Group:** Sanjay Kumar Rakesh Kumar J. P. Patra Pankaj Mani **DOS:** April 2017 **DOC:** March 2021	Dr. Sanjay Kumar presented the study and stated that the study specifically focuses on developing design flood estimation methods for ungauged regions based on the concept of regionalization using L-moments approach. He stated that at site frequency analysis based on L-moments approach for eleven sites (for GEV distribution) has been completed. The results of NAM model calibration for one sub-basin and its applicability in other (ungauged) sub-basins using calibrated NAM parameters were also reported based on the use of IMD gridded rainfall data. Limitation of using gridded rainfall data in the un-gauged basins was highlighted. Chairman suggested to examine the use of area weighted NAM parameters in un-gauged basins for possible improvements.
4.	Study of hydrological changes in selected watersheds in view of climate change in India (Ongoing). **Study Group:** L.N. Thakural S. Rathore Surjeet Singh Sanjay Kumar Jain Shard Kumar Jain **DOS:** April 2015 **DOC:** March 2020	Dr. Thakural presented the GIS database created to meet out the objectives of the study using Digital Elevation Model (DEM) and satellite imagery for flow accumulation, stream network, watershed boundary, Land use/Land cover thematic maps in addition to soil map for the four watersheds. Spatio-temporal analysis of hydro-meteorological data using parametric and non-parametric approaches for the Ramganga, Bina and Chaliyar river basins were also presented. The outcomes/results of hydrological models (NAM and SWAT) were presented. To study the impact of climate change, gridded rainfall and temperature data, historical NCEP/NCAR reanalysis data (observed predictors) and GCM Predictor grid boxes for the four river basins processed to generate RCP2.6 RCP 4.5, RCP 6 and RCP 8.5 using statistical downscaling model (SDSM) were presented. The model calibration and validation for the rainfall and temperature using NCEP reanalysis data for the RCP 2.6, 4.5, 8.5 were also presented. Members inquired about the gridded data being used. Dr. Thakural mentioned that these data were obtained from various national and international sources available in public domain. Dr. Thakural also requested to allow extension of one year for the study to further investigate the impact of climate change which was agreed.
5.	Development of regional methods for design flood estimation in Uttarakhand (Ongoing). **Study Group:** J.P. Patra Rakesh Kumar	Mr. Jagadish Prasad Patra, presented the objectives and need of the study with brief methodology. The progress made for at-site flood frequency analysis using L-moments approach for annual maximum peak flood series data obtained from CWC were presented. The relationships developed to estimate design flood for various return periods with catchment area were also presented. The progress made

	Pankaj Mani Sanjay Kumar **DOS:** April 2017 **DOC:** March 2020	in Nonstationary Extreme Value Analysis considering the aspect of non-stationary in the data series was presented for one of the sites. The effect of Tehri dam operation for moderation of flood peaks at Rishikesh, Haridwar etc. as well as the hypothetical dam at Alaknanda river were explained.
6.	Evaluation of seasonal extreme rain events across river basins of India in 3D global temperature change scenario (Ongoing). **Study Group:** Ashwini Ranade Archana Sarkar **DOS:** April 2018 **DOC:** March 2021	Dr. Ashwini Ranade presented important results from the first objective. Working Group noted the work on updation of eleven major and nine independent minor river basin rainfall series and the results obtained from trend analysis for understanding the recent changes in rainfall pattern across India.
7.	Assessment of Climate Change Impact on Water Availability and Agriculture in part of Banas basin. **Study Group:** Archana Sarkar Surjeet Singh Suman Gurjar Sunil Gurrapu **DOS:** Dec. 2018 **DOC:** Dec. 2020	Dr Archana Sarkar presented the background and objectives of the study. She informed that the Banas river basin up to Bisalpur dam and the irrigation command are located in the State of Rajasthan in western India has been selected as the study area. Trend analysis of the historical & future patterns of rainfall and temperature time series in Banas basin and command area is being carried out using modified Mann-Kendall's technique and Sen's Slope method and presented the preliminary results. The future time series data is being taken from the GCM downscaled data of the Copernicus website which consists of data of 19 GCMs under two RCPs (RCP4.5 & RCP 8.5). Dr R.K. Goyal advised not to use the CROPWAT software due to huge data requirements and use simple methods for the same. Dr. S.S. Grewal advised to carry out the trend analysis of rainfall events producing runoff using historical data of rainfall.
8.	Evaluation of the influence of low-frequency-atmosphere-ocean oscillations on annual floods in the watersheds of the Indian subcontinent. **Study Group:** Sunil Gurrapu Ashwini Ranade J.P. Patra **DOS:** Dec. 2018 **DOC:** Dec. 2021	Mr. Sunil Gurrapu, Scientist C and PI of the study was on official tour, hence Mr. Jagadish Prasad Patra, presented the progress of the study and explained that the Narmada basin and Godavari basin are identified for evaluating influence of various low-frequency atmosphere-ocean oscillations on flood magnitude and frequency. It was informed that the data of 31 gauging sites have been collected and PDO indices, Southern Oscillation Index (SOI), Dipole Mode Index (DMI), etc. are being collected from various international agencies. During the presentation, committee members suggested to include name of the basin in the title of the study.
9.	Evaluation of Water Quality of Government Schools in Roorkee Block, District Haridwar. **Study Group:** N. K. Bhatnagar M. K. Sharma L. N. Thakural Reena Rathore **DOS:** Dec. 2018 **DOC:** Dec. 2020	Sri NK Bhatnagar presented the objectives of the study and progress. Dr Ramakar Jha inquired whether sampling could be done on weekly instead of pre-monsoon and post-monsoon basis as it is being done in CGWB. Dr. Mukesh Sharma replied that water quality sampling is done during pre and post-monsoon only. Dr. Sudheendra Sharma inquired whether water samples are collected from hand pumps of Schools. It was informed that the samples will be collected as suggested by the Working Group members.

NEW STUDIES(INTERNAL)		
10.	Development of drought monitoring system for early warning and preparedness for a selected region in	Dr. R.P. Pandey informed that the primary purpose of the proposed project is to develop a scientific tool for regular drought monitoring and early warning system (EWS) for preparedness in drought

	India **Study Group:** R.P. Pandey D.S. Rathore Ravi Galkate Sunil Gurrapu Suman Gurjar **DOS:** May 2019 **DOC:** March 2022	affected Bundelkhand region. Chairman WG suggested to recast some the objectives of the study. Accordingly, objectives of the study have been revised as: 1. Identification and evaluation of key hydro-meteorological indicators/indices for monitoring and assessment of drought and severe water scarcity condition. 2. Development of base maps showing demarcation of areas vulnerable to drought using physiographic, climatic and social factors including demarcation of rainfed and irrigated areas. 3. Development of systematic database setup and computation programs for different drought indices/techniques. 4. Development of composite program and dashboard with menu driven generic system for various drought indicators/ indices linked with common data base. 5. Customization of drought monitoring system for district/sub-district level assessment. 6. Evaluation and result verification with field observations. 7. Hosting of the EWS/drought monitoring system on the NIH website. Dr Dimri suggested to explore possibility to include soil heat flux index as one of the early warning indicator. Dr S.P. Agrawal suggested to contact MNCFC and NRSC to obtain input and support for the proposed monitoring and early warning system. Dr Man Singh informed that IARI is working with the University of Nabraska, USA to develop a composite index for drought monitoring. He suggested to share the proposal with him for providing suitable inputs. Director, NIH suggested to send the proposal to IARI seeking comments and input for the proposed study, and to include Dr. T. Thomas, Sc D, RC Bhopal in the study team.

WATER RESOURCES SYSTEMS DIVISION

SUGGESTION/ COMMENTS RECEIVED FROM MEMBERS DURING 48th WORKING GROUP MEETING

Dr. Sanjay K Jain, Sc. G and Head, presented an overview of the division – scientific strength, the ongoing studies, sponsored & consultancy studies, technical publications and training courses organized. Thereafter scientists of the division presented their studies. Following are the comments received from working group on the presentations of the various studies:

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

2. ***Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh (Completed)***

RJT presented this completed project which established the characteristics of the Himalayan permafrost for the first time. He elaborated on the field monitoring of GST in the Ganglass catchment Ladakh and modelling of soil temperature upto 10m using the measured GST distributed at 12 plots between 4727 -5610 m a.s.l. Core permafrost characteristics such as Surface offset, thermal offset, active layer thickness variations, Mean Annual Ait Temperature (MAAT) are discussed. He has shown that the site at 4727 m a.s.l. did not show the permafrost signatures while the site at 4900 m a.s.l. has strong permafrost presence. Active layer thickness in the catchment vary between 4.3 m to 0.3 cm at higher elevation regions. The spatial distribution of permafrost is assessed by regression models and suggest around 95% permafrost cover in the catchment. RJT acknowledged the collaboration and assistance with Carleton University, Ottawa, Canada and ICIMOD, Nepal.

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

1. Hydrological Processes and Characterization of Lesser Himalayan Catchments (Ongoing)

The progress of the study was presented by MKN. It was informed that all proposed instrumentation have been installed in the experimental catchment and data is being received at NIH, Roorkee. Soil monitoring station (COSMOS) has also been established at project site. Analysis and time series graphs of few of the meteorological, hydrological and lithological variable were presented. The results of the evapotranspiration (ET) estimated by Eddy-covariance (EC) flux tower were compared with the ET estimates by Penman-Monteith method.

PI: Deepa Chalisgaonkar, Scientist "G"

2. ***Development of window based software for hydrological data processing and Unit Hydrograph Analysis (Ongoing)***

Mrs. Deepa presented the progress of the project. She informed that a user friendly software in vb.net platform has been developed for hydrological data processing and unit hydrograph analysis for the estimation of flood for gauged as well as ungauged catchments of small and medium size catchments. Online help for the software is available and the package is capable of displaying the results in tabular and/or graphical form.

3. ***Development of window based software for Flood Estimation (New)***

Mrs Deepa presented the proposed study. She informed that this software will be used for the flood estimation of large catchments. At the later stage, the unit hydrograph package can be merged into this package so that a comprehensive software for flood estimation and small, medium and large catchments will be developed.

PI: Dr. P. K. Singh (PKS), Scientist "D"

1. Developments of Water Accounts for Subarnarekha Basin Using Water Accounting Plus (WA+) Framework (Ongoing)

PKS presented the ongoing study and relevance of global data used in WA+ as input, before presenting the results on Sheet 2 and Sheet 3 on evapotranspiration from the basin and land and water productivity respectively. He also discussed on the data biasness in global rainfall data particularly CHIRPS and TRMM products w.r.t the IMD rainfall data. Dr. R. K. Goyal from CAZRI desired to organize a training programme as well as execute a research project work on WA+ for the basins of Rajasthan with the scientists from NIH. Dr. Ambrish Kumar, Principal Scientists, IISWC, Dehradun also evinced his interest to deliver lectures on WA+ at IISWC for which he will soon communicate.

PI: Dr. Vishal Singh (VS), Scientist "C"

1. Real time flood modelling using HEC-RTS modelling framework (Ongoing)

VS presented study on Real time flood modelling using HEC-RTS framework in Periyar river basin. He briefly presented the different components under HEC-RTS. He also shared the preliminary findings of flood modelling. Few members suggested the following:

- Use of different rainfall dataset which has less bias.
- Use of WRF model for the prediction of more accurate rainfalls for the flood event.
- Revisiting the reservoir rules for Mullaperiyar dam.
- Use of High resolution DEM for flood inundation modeling and mapping the flood extent.

PI: D. S. Rathore, Scientist "F"

3. ***Design and development of DSS (H) platform for Neeranchal National Watershed Project (Ongoing)***

The study was not presented since it was dropped by the sponsoring agency.

4. Investigating water stress using hydro-meteorological and remote sensing data (Ongoing study under NHP-PDS)

Mr D.S. Rathore informed that various data e.g. precipitation, and groundwater level data, technical reports etc. were collected from Water Resources Department and State Groundwater Board. The validation of the data is in progress. Missing daily precipitation data were observed and gap filling will be carried out. Declining trend in groundwater was observed in both pre and post groundwater levels. For last 15- 20 years, several wells and piezometers remain dry in summer. Nearly 2.5 MCM storage is created by small and medium size water harvesting structures in the basin. Procurement of equipment namely soil moisture profile probe and digital tipping bucket raingauge with datalogger is initiated. Satellite data products were browsed for initiating their purchase. R script was written for data filling using linear/ multiple linear regression technique. For spatio- temporal analysis, bfastspatial R-package was selected and was applied to sample data.

PI: Dr. M. Arora (MA), Scientist "D"

1. Modeling of Gangotri Glacier melt runoff and simulation of stream flow variation under different climate scenarios (Ongoing study)

MA presented the progress of the study. No specific comments were received from the members.

PI: Dr. M. K. Goel (MKG), Scientist "G"

3. Study title: National Mission for Sustaining the Himalayan Ecosystem (NMSHE) (Ongoing)

MKG initiated the combined presentation on NMSHE sub-projects where-in six presentations for six sub-projects of NMSHE (in which Scientists of WRS Division are involved) were made.

Sub-project – 1: Development of a project website and hydrological database in Upper Ganga Basin (PI-Dr. M. K. Goel, Sc-G)

No specific comments were received from the members.

Sub-project – 2: Real-time snow cover information system for Upper Ganga basin (PI-Mr. D. S. Rathore, Sc-F)

The study was presented by Dr. M.K. Goel. It was informed that post processing procedure (with altitude mask and temporal filter) was implemented in R-software as a semi-automated method. The method was applied to Upper Ganga and Subansiri and adjoining basins. The script will further be modified to calculate zone wise area. Dr S.P Aggarwal inquired whether topographic aspect was considered in applying the altitude based masking in post processing. Mr. Rathore replied that aspect was not considered in this post processing procedure of altitude mask. Present method will provide initial snow cover estimates and will be useful as an input in hydrological models.

Sub-project – 3: Glacial Lakes & Glacial Lake Outburst Flood (GLOF) in Western Himalayan Region (PI-Dr. Sanjay K. Jain, Sc-G)

No specific comments were received from members.

Sub-project – 4: Assessment of downstream impact of Gangotri glacier system at Dabrani and future runoff variations under climate change scenarios (PI-Dr. Renoj J. Thayyen, Sc-D)

No specific comments were received from members.

Sub-project – 5: Observation and modelling of various hydrological processes in a small watershed in Upper Ganga basin (PI-Dr. Sharad K. Jain, Sc-G)

No specific comments were received from members.

Sub-project – 11: Water Census and Hotspot analysis in selected villages in Upper Ganga basin (PI-Dr. P. K. Mishra, Sc-C)

No specific comments were received from members.

WORK PROGRAMME FOR THE YEAR 2019-2020

SN	Title	Study Team	Duration	Funding (Rs. in Lakhs)
Ongoing Internal Studies				
1.	Hydrological process and characterization of Lesser Himalayan Catchments	M. K. Nema Sharad K. Jain, Sanjay K. Jain, Renoj J.Thayyen, P. K. Mishra	5 years (12/14-12/19)	
2.	Developments of Water Accounts for Subarnarekha Basin Using Water Accounting Plus (WA+) Framework	P. K. Singh P. K. Mishra, M. K. Goel, Suman Gurjar	2 years 2018-2020	
3.	Real time flood modelling using HEC-RTS framework	Vishal Kumar A. K. Lohani, Sanjay K. Jain	2 years 2018-2020	
Ongoing Sponsored Studies				
1.	Development of a project website and hydrological database in Upper Ganga Basin **(Sub-project – 1)**	M. K. Goel M. Arora, A. K. Lohani, D. S. Rathore, D. Chalisgaonkar, P. Mani, P. K. Mishra	5 years (01/16-12/20)	DST (52.15)
2.	Real-time snow cover information system for Upper Ganga basin **(Sub-project – 2)**	D. S. Rathore D. Chalisgaonkar, V. S. Jeyakanthan, L. N. Thakural	5 years (01/16-12/20)	DST (48.83)
3.	Glacial Lakes & Glacial Lake Outburst Flood (GLOF) in Western Himalayan Region **(Sub-project – 3)**	Sanjay K. Jain A. K. Lohani, Sudhir Kumar, P. Thakur (IIRS)	5 years (01/16-12/20)	DST (36.79)
4.	Assessment of downstream impact of Gangotri glacier system at Dabrani and future runoff variations under climate change scenarios **(Sub-project – 4)**	Renoj J.Thayyen Sanjay K. Jain, Sharad K. Jain, P. K. Mishra, M. Arora, AP Dimri (JNU)	5 years (01/16-12/20)	DST 51.43 (NIH) + 28.29 (JNU)
5.	Observation and modelling of various hydrological processes in a small watershed in Upper Ganga basin **(Sub-project – 5)**	Sharad K. Jain Renoj J.Thayyen, Sanjay K. Jain, Surjeet Singh, M. K. Nema , P. K. Mishra, P. K. Agarwal, AP Dimri (JNU)	5 years (01/16-12/20)	DST (54.07)
6.	Water Census and Hotspot analysis in selected villages in Upper Ganga basin **(Sub-project – 11)**	P. K. Mishra M. K. Nema, Renoj J. Thayyen, P. K. Sachan	5 years (01/16-12/20)	DST (90.99)
7.	Dynamics of Himalayan Ecosystem and its impact under changing climate scenario-Western Himalaya	Renoj J.Thayyen P. K. Mishra	3 years (03/17-03/19)	NMHS-MoEF (58.76 lakh)
8.	Measurements and Modeling of Evapotranspiration and other Hydrological Processes in Lesser Himalayas	M K Nema Renoj J. Thayyen, Sharad K. Jain, Sanjay K. Jain, P. K. Mishra, AP Dimri (JNU)	3 years (2016-19)	MOES (Rs. 98 Lakh)
9.	Sustaining Himalayan Water Resources in a Changing Climate (SusHi-Wat)	Sanjay K. Jain (PI) Sharad K. Jain CSP Ojha (PI, IITR)	3 years (2016-2019)	MOES-NERC, Newton-Bhabha project

				(11.59 Lakh)
10.	Investigating Water Stress using Hydro-meteorological and Remote Sensing data	D. S. Rathore L. N. Thakural, Sanjay Kumar, B. Venkatesh, M. K. Jose, T. Chandramohan	3 years 2017-2020	PDS under NHP
11.	Seasonal Characterization of Gangotri Glacier melt runoff and simulation of streamflow variation under different climate scenarios	M. Arora Deepak Singh Bisht, Sanjay K. Jain	3 years 2018-2021	NIH
		New Internal Studies		
1	Development of windows based software for Flood Estimation	D. Chalisgaonkar A. K. Lohani, M. K. Goel	1 year (04/19-03/20)	

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)

SN	Title of Project/Study, Study Team	Status and Recommendations/Suggestions
1.	**Study on effect of climate change on sediment yield to Pong reservoir.** **Team:** A. R. Senthil kumar, J. V. Tyagi, S. D. Khobragade and Manohar Arora DOS: Apr 2015, DOC: June 2019	Dr Senthil kumar (PI) presernted the discharge and sediment yield at Nadaun Brdige (Pong reservoir) simulated using SWAT with data from ERA INTERIM. The downscaling of rainfall, maximum and minmum temperature for the sceanrios RCP2.6, 4.5 and 8.5 were carried using SDSM from CanESM2 using IMD gridded data from 1961 to 2005 and bias corrected by the probability of exceedence method. The discharge and sediment yield were simulated using IMD data of rainfall, maximum and minimum temperature for data from 1987 to 2005. The discharge was well simulated but sediment yield was poorly simulated. Prof Dimri suggested to find reason behind poor simulation of sediment yield and if not improved, the same may be reported in final report. The Chairman suggested all team members to try to fix the problem and complete the study by June 2019.
2.	**Bathymetric survey and water quality monitoring of selected ponds in Bundelkhand region for development of water management plan.** **Team:** Digambar Singh**,** Omkar Singh, Subhash Kichlu, Rajesh Kumar Nema, Hukum Singh and N R Allaka DOS: Apr 2018, DOC: March 2020	The study could not be presented due to paucity of time.
3.	**Conservation of ponds in Ibrahimpur- Masahi Village and performance evaluation of natural treatment system** **Team:** Omkar Singh, V C Goyal, Rajesh Singh, Digambar Singh, Subhash Kichlu, Rajesh Agarwal, Rakesh Goel & N R Allaka **Partern Organization:** Prof. Laurence Carvalho & Team, Centre for Ecology	Sh. Omkar Singh (PI) infomed that weekly/ quarterly water and wastewater sampling is going on from both ponds (CW-NTS pond at Ibrahimpur Masahi and control pond at Masahi Kala). CEH-UK team is also visiting periodically to collect samples from the both ponds and providing data on GHG emissions and biota. Dr. Sadhana Malhotra desired to know about maintenance of CW-NTS at village pond. The PI & Co-PI replied their queries.

	& Hydrology (UK). DOS: Apr 2018, DOC: March 2020	
4.	**Vulnerability Assessment to Climate Change in Chhattisgarh** **Team:** Dr Jyoti P Patil, Scientist C and Ms Meeta Gupta, JRF DOS: July 2017, DOC: June 2019	This study was taken up under NNWP but is now converted to internal study due to closure of NNWP. Accordingly, title of the study is also changed. The objectives, brief methodology and results of the study were presented by Dr Jyoti Patil. The scheduled date of completion of this study is June 30, 2019 and analysis for two districts in Chhattisgarh is completed.
5.	**Hydrological modelling in Bhagirathi basin up to Tehri dam and assessment of climate change impact** **Team:** A R Senthil kumar, J. V. Tyagi, M. K. Goel, S. D. Khobragade, P. C. Nayak, Manohar Arora and Digambar Singh DOS: July 2016, DOC: June 2021 (**NMSHE**)	Dr. Senthil kumar (PI) mentioned that the discharge and sediment yield at Tehri dam was simulated using SWAT by considering the parameters randomly initially and input data obtained/generated from different sources. The discharge was simulated fairly good and the sediment yield was poorly simulated. The Chairman suggested to discuss with team members to sort out the problem.
6.	**Development of water allocation plan of watershed in Kanker district, Chhattisgarh** **Team:** A. R. Senthil kumar, Jyoti P Patil, T R Nayak and Rajesh Agarwal DOS: Apr 2018, DOC: March 2020	Dr. A. R. Senthil kumar (PI) mentioned that the WEAP model was setup for micro watersheds IWMP14 and IWMP15 of Kanker Districts Chhattisgarh. Results such as water demand, runoff generated, demand site inflows and outflows, unmet demand, reliability of demand met were presented for the base period (2015). The same output for reference period from 2016 to 2050 were being extracted from the results.
7	**Rejuvenation of village ponds for identified villages in Muzaffarnagar and Meerut districts** **Investigators:** V C Goyal, Omkar Singh, Rajesh Singh, Digambar Singh **Scientific/Technical Staff:** Subhash Kichlu, Rajesh Agarwal, Rakesh Goel, N. R. Allaka DOS: April 2017, DOC: March 2020	The technical progress of the study was presented by Er. Omkar Singh, Sc. F. The status regarding onsite rejuvenation work of 12 ponds as carried out by the NPCC, which is in an advanced stage, was also presented.
8	Rejuvenation of Village Ponds in Identified Villages of Baghpat, Ghaziabad and Meerut Districts of Uttar Pradesh **Investigators:** Omkar Singh, Rajesh Singh, V. C. Goyal, Digambar Singh **Scientific/Technical Staff:** Subhash Kichlu, Rajesh Agarwal, Rakesh Goel, N. R. Allaka DOS: Jan. 2018, DOC: Dec. 2020	The technical progress of the study was presented by Er. Omkar Singh, Sc. F. The status regarding onsite rejuvenation work of 9 ponds as carried out by the NPCC, which is in the advanced stage was also presented. There were no specific comments from working group members.
9	**Innovation Centre for Eco-Prudent Wastewater Solutions (IC-EcoWS)** **Team:** V.C. Goyal (PI) **Partners:** NIH, NIT-Jaipur, IIT-Bombay, IRMA-Ahmedabad DOS: Apr 2019, DOC: Mar 2024	The overview of the project was given by Dr. V. C. Goyal, Sc. G & Head (PI). The PI informed that an Inception cum-Need Assesment workshop is scheduled during 24-25 June 2019 at NIH Roorkee

WORK PROGRAMME FOR THE YEAR 2019-20

SN	Title of Project/Study	Funding	Study Team	Duration	Status
Internal Study					
1	Study on effect of climate change on sediment yield to Pong reservoir	NIH	A R Senthil kumar (PI) J V Tyagi, S D Khobragade , Manohar Arora	Apr 2015-Mar 2018 (extended up to June 2019)	On-going
2	Bathymetric survey of identified ponds in the districts of Muzaffarnagar, Meerut, Ghaziabad and Baghpat (UP) for development of water management plan	NIH	Digambar Singh (PI) Omkar Singh Rajesh K.Nema Hukam Singh N R Allaka	Apr 2018-Mar 2020	On-going
3	Conservation of ponds in Ibrahimpur- Masahi Village and performance evaluation of natural treatment system	NIH,CEH (UK)	**NIH**: Omkar Singh (PI) V C Goyal, Rajesh Singh, Digambar Singh, Subhash Kichlu, Rajesh Agrawal, Rakesh Goel, NR Allaka **CEH-UK**: Prof. Laurence Carvalho & Team	Apr 2018-Mar 2020	On-going
4	Development of DSS for Watershed Hydrology	NIH	V C Goyal (PI) Jyoti Patil, Rohit Sambare	May 2019-Aug 2019	New
	Sponsored Projects				
1	Vulnerability assessment of identified watersheds in Chhatisgarh	NNWP (under NIH scheme)	Jyoti P Patil (PI)	Jul 2017- Jun 2019	On-going
2	Hydrological modelling in Bhagirathi basin up to Tehri dam and assessment of climate change impact	DST (under NMSHE)	A R Senthil kumar (PI) J. V. Tyagi, M. K. Goel, S. D. Khobragade, P. C. Nayak, Manohar Arora	Mar 2016-Mar 2021	On-going
3	Rejuvenation of village ponds for identified villages in Muzaffarnagar and Meerut districts of UP	MoWR-funded project-Through INCSW	V C Goyal (PI) Omkar Singh, Digambar Singh, Rajesh Singh, Subhash Kichlu, Rajesh Agrawal, Rakesh Goel, NR Allaka	Apr 2017-Mar 2020	On-going
4	Rejuvenation of village ponds in identified villages of Baghpat, Ghaziabad and Meerut districts of Uttar Pradesh	MoWR-funded project (through Scheme funds)	Omkar Singh (PI), Rajesh Singh, V C Goyal, Digambar Singh, Subhash Kichlu, Rajesh Agrawal, Rakesh Goel, NR Allaka	Apr 2017-Mar 2020	On-going
5	Development of water allocation plan for identified watersheds in Kanker district (Chhattisgarh)	NNWP (under Scheme funds)	A R Senthil kumar (PI) T R Nayak, Jyoti P Patil, Rajesh Agarwal	Apr 2018-Mar 2020	On-going
New Sponsored Project					
6	Innovation Centre for Eco-Prudent Wastewater Solutions (IC-EcoWS)- establishment and	DST (GoI), Cost: Rs.	Partners: NIH, MNIT-Jaipur, IIT-Bombay, IRMA-Ahmedabad	Jun 2019-Mar 2024	New Project

	operation of 'Live Laboratory' in a rural setting near Roorkee	5.1 Crore	V.C. Goyal (PI), Omkar Singh, Rajesh Singh, Rohit Sambare		

Proposed Trainings/Workshop/Activities:

S.No.	**Name of activity**	Funding	Team/Div.	Period	Venue
1	Inception cum-Need Assessment of IC-EcoWS Project	DST (GoI)	V.C. Goyal (PI), Omkar Singh, Jyoti Patil, Rajesh Singh, Rohit Sambare	24-25 Jun, 2019	NIH Roorkee/MNIT Jaipur
2	Networking Project on Rejuvenation of Ponds-Review Meeting	DST (GoI)	T. Thomas (PI), Jyoti Patil	14-15 Jun, 2019	NIH Roorkee
3	National Workshop on Scientometrics	NIH	V C Goyal (PI), Archana Sarkar, Rohit Sambare, Furqan Ullah, Charu Mishra	Feb 2020	NIH Roorkee

Expected Outreach Activities:

S.No.	**Name of activity**	Funding	Team/Div.	Period	Venue
1	India Water Week	NIH	RMOD	24-28 Sep 2019	Vigyan Bhawan, New Delhi
2	India International Trade Fair	NIH	RMOD	14-27 Nov 2019	New Delhi
3	Indian Science Congress	NIH	RMOD	3-7 Jan 2020	UAS, Bangalore
4	Any other Outreach activity on demand/assigned	NIH	RMOD		

List of activities proposed under INC-IHP during 2019-20

Meetings to be organised/ attended

1. Meeting of INC-IHP, during May/June 2019, after obtaining approval on re-constitution of committee from the Ministry
2. 24th session of the InterGovernmental Council (IGC) of the International Hydrological Programme of UNESCO, Paris, France
3. 27th meeting of the IHP Regional Steering Committee for Asia and the Pacific, to be held at Myanmar in 2019
4. Participation in Asian GWADI meeting
5. Participation of Indian nominees in various UNESCO meetings

Thematic Trainings:

1. Training course on 'Water Security Assessment' during July 2019 (Location: New Delhi/ Roorkee)
2. Training course on 'Water Education- Key for Water Security' during March 2020 (Location: New Delhi/ Roorkee)

Brainstorming sessions/ exhibitions during conferences/ summits

Sl. No.	INC-IHP proposed event	Conference/ Summit	Host Organisation	Location	Date
1.	Exhibition on R&D in Hydrology, Wastewater treatment	3rd World Water Summit 2019	Energy and Environment foundation	New Delhi	21-23 Aug, 2019
2.	Brainstorming session on Theme-V 'Ecohydrology-Engineering Harmony for a Sustainable World'	Water future Conference	IISc, Bengaluru	Bengaluru	24-27 Sep, 2019
3.	Session on 'Enhancing sustainable groundwater resources management'	8th Int. Groundwater Conference on Sustainable Management of Soil-Water Resources	IIT-Roorkee	Roorkee	21-24 Oct, 2019
4.	Theme- Water-related Disasters and Hydrological Changes	Int. Conf. on Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security	Soil Cons. Society of India (SCSI), New Delhi	New Delhi	5-9 Nov, 2019
5.	Theme- Game-changing approaches and technologies	Int. Conference on Future Cities	IIT-Roorkee	Roorkee	11-13 Dec, 2019
6.	Theme- Promoting innovative tools for safety of water supplies and controlling pollution	HYDRO-2019 (Hydraulics, Water Resources and Coastal Engineering)	Osmania University, Hyderabad	Hyderabad	18-20 Dec, 2019
7.	Theme- Water Education- Key for Water Security	Roorkee Water Conclave 2020	IIT-Roorkee and NIH	Roorkee	26-28 Feb, 2020
8.	Celebration of World Water Day		NIH, jointly with UNESCO New Delhi	New Delhi	22 Mar 2020

Dr. V C Goyal thanked the members for their valuable contributions during deliberations in the Working Group meeting. The WG members desired to form a Whatsapp group of WG members.

The meeting ended with vote of thanks to the Chair.

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ANNEXURE-I

List of Working Group Members who attended the 48th WG meeting

1.	Dr. S.K. Jain, Director, NIH	Chairman
2.	Sh. Wasim Ahmed, CGWB, Dehradun	Member
3.	Dr. K V Singh, IMD, New Delhi	Member
4.	Dr. Ambrish Kumar, ICAR-IISWC, Dehradun	Member
5.	Dr. R D Deshpande, PRL, Ahmedabad	Member
6.	Dr. S P Aggarwal, IIRS, Dehradun	Member
7.	Dr. R K Goyal, ICAR-CAZRI, Jodhpur	Member
8.	Sh. Man Singh, WTC, ICAR-IARI, New Delhi	Member
9.	Prof. A K Saraf, IIT, Roorkee	Member
10.	Prof. M L Kansal, IIT, Roorkee	Member
11.	Dr. S S Grewal, Chandigarh	Member
12.	Dr. Kaushal K. Garg, ICRISAT, Hyderabad	Member
13.	Prof. Ramakar Jha, NIT, Patna	Member
14.	Prof. A P Dimri, JNU, New Delhi	Member
15.	Dr. Sadhana Malhotra, Mindspace, Dehradun	Member
16.	Sh. Sudhindra Mohan Sharma, Indore	Member
17.	Dr. Anil Guatam, PSI, Dehradun	Member
18.	Dr. Rakesh Kumar, Sc. G & Head SWH Division, NIH	Member
19.	Dr. J V Tyagi, Sc.G & Head EH Division, NIH	Member
20.	Dr. Sudhir Kumar, Sc. G & Head HI Division, NIH	Member
21.	Er. C P Kumar, Sc.G & Head GWH Division, NIH	Member
22.	Dr. Sanjay K. Jain, Sc. G & Head WRS Division, NIH	Member
23.	Dr. V C Goyal, Sc. G & Head, RMO Division, NIH	Member-Secretary

Scientists from National Institute of Hydrology

	EH Division		**SWH Division**
1	Dr. M.K. Sharma, Sc.D	23	Dr. A.K. Lohani, Sc.G
2	Dr. Rajesh Singh, Sc.C	24	Dr. R.P. Pandey, Sc.G
3	Dr. Pradeep Kumar, Sc.C	25	Dr. Sanjay Kumar, Sc.E
4	Dr. Swapnali Barman, Sc.C	26	Dr. Archana Sarkar, Sc.D
5	Sh. Rajesh K. Nema, Sc.B	27	Dr. L.N. Thakural, Sc.C
	GWH Division	28	Sh. J.P. Patra, Sc.C
6	Dr. Anupama Sharma, Sc.E	29	Dr. Ashwini A. Ranade, Sc.C
7	Dr. Surjeet Singh, Sc.E	30	Sh. N K Bhatnagar, Sc.B
8	Er. Sumant Kumar, Sc.C		**WRS Division**
9	Mrs. Suman Gurjar, Sc.C	31	Dr. M.K. Goel, Sc.G
10	Dr. Gopal Krishan, Sc.C	32	Smt. Deepa Chalisgaonkar, Sc. G
11	Sh. Nitesh Patidar, Sc.B	33	Er. D.S. Rathore, Sc.F
	HI Division	34	Dr. Renoj J. Thayyen, Sc.E
12	Dr. Suhas Khobragade, Sc.F	35	Dr. Manohar Arora, Sc.D
13	Dr. M.S. Rao, Sc.E	36	Dr. P K Singh, Sc.D
14	Sh. S.K. Verma, Sc.D	37	Er. Manish Nema, Sc.C
15	Dr. Santosh M Pingale, Sc.C	38	Dr. P K Mishra, Sc.C
16	Sh. Hukam Singh, Sc.B	39	Dr. Vishal Singh, Sc.C
17	Ms. Nidhi Kalyani, Sc.B	40	Sh. P K Agarwal, Sc.B
	RMO Division	41	Sh. Deepak Singh Bisht, Sc.B
18	Er. Omkar Singh, Sc.F		
19	Dr. A R Senthil Kumar, Sc.F		

20	Sh. Digamber Singh, Sc.C		
21	Dr.(Mrs) Jyoti P. Patil, Sc.C		
22	Sh. Rohit Sampatrao Sambare, Sc.B		